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THE STANDARDIZATION OF X-RAY DOSAGE¹

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IF WE wish to reach international agreement on the standardization of the roentgen ray dose measurement, we must give careful consideration to all suggestions which are made with this purpose in view. In so doing we find that the early proposal of Villard, which was at first unsuccessful, since it had not been sufficiently investigated, after all seems to be the best. There is also another proposal which comes from France and to which we must give serious consideration, *i.e.*, the Solomon unit.

Solomon wished to define his unit with the same instrument which he uses in practice on patients. This instrument is a small ionization chamber, connected to an electro-scope. It would be a considerable progress if this method could be made to be universally adopted and correct for any instrument, but we shall see that this is impossible, because the unit defined by Solomon depends upon the kind of instrument which is used. Solomon's definition is as follows: "One R-unit is that intensity of X-radiation which produces the same ionization as one gram of radium element at a distance of 2 cm. from the ionization chamber, when the radium rays are filtered through 0.5 mm. platinum." In later publications Solomon has described more accurately and in detail the arrangement of the radium and the ion-

ization chamber which he uses in calibrating his dosimeter. There is no doubt but that this method gives satisfactory results if the same measuring apparatus is always used. If, however, we are employing different types of dosimeters, we usually obtain different values for the unit of dose and also the unit value will change with the quality of the radiation. This has been demonstrated several times, especially as reported in a recent paper by Murdoch and Stahel. The reasons for these differences lie mainly in the influence of the material used in the construction of the walls of the ionization chamber. This was demonstrated in detail by the work of Fricke and Glasser, who showed that a small chamber gives the true air ionization only when it consists of material which has the same effective atomic number as the atmospheric air, *i.e.*, 7.69. Therefore Solomon prescribes that the material of the chamber must be graphite, or, still better, a material of the kind described by Fricke and Glasser.

We have made a number of experiments with small ionization chambers, especially in regard to their calibration with radium. The apparatus which we used in our experiments was simply a string electroscope with a tubing to which the different chambers to be investigated could be connected.

At first we compared the ionization current per cubic centimeter volume of small chambers of different sizes and materials

¹Read before the Radiological Society of North America, at New Orleans, Nov. 30, 1927.

with the ionization current from a standard ionization chamber, a cask chamber or a compressed air chamber. We observed the same results which had been described by Fricke and Glasser, especially that chambers

erred with foils of different materials, and, also, the quality of the rays is changed. If no magnetic field is used the ionization current in the chamber is always designated as one hundred. Thus, the other values are

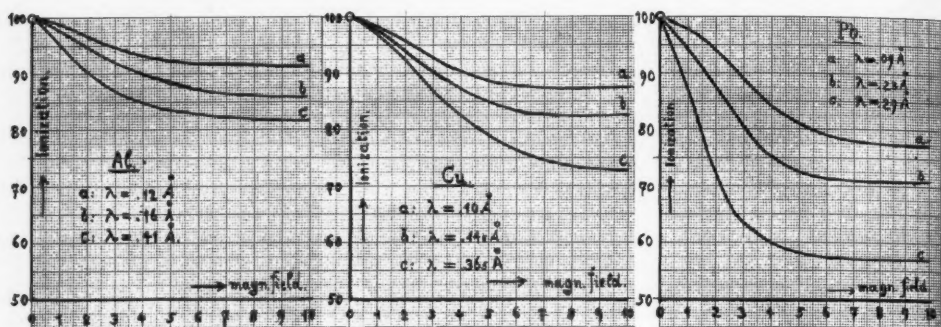


Fig. 1-A.

Fig. 1-B.

Fig. 1-C.

of the heavier materials with a high atomic number produce comparatively too much ionization. It was found to be somewhat difficult to obtain the pure ionization in air by using chambers of a light material because the addition of very small quantities of heavier elements causes the ionization to increase considerably. It is necessary, therefore, to use highly purified substances, which are not always easily obtainable. Graphite, especially, usually contains impurities. By the well known work of Fricke and Glasser it was deduced that this great influence of small traces of heavy elements is due to the rapid increase of the true absorption as the effective atomic number increases, because the photo-electrons have a considerable preponderance over the Compton electrons, especially when softer rays and heavy elements are used. By bringing the ionization chamber into a magnetic field of increasing power it can easily be shown that we are dealing with two different kinds of electrons (Fig. 1). This is illustrated by several curves which give the ionization current of the same small chamber when the inside of the chamber is cov-

given in percentages. It is shown distinctly that the magnetic field removes part of the ionization electrons; others, however, are not influenced.

If the magnetic field has sufficient power to completely remove one kind of electrons, any increase of the field no longer has an effect. This suggests that the removable electrons are photo-electrons and the rest are the Compton electrons. At least there are reasons for such an interpretation. These are, for example, the increase of the influence of the field with softer rays or with heavier chamber materials. For the lightest materials, such as carbon, there is scarcely any effect observable.

These last remarks refer only to the influence of the chamber walls and this influence is due to the electrons which are liberated on the inner surface. However, there is also another influence which really may be considered as two influences. The first is the absorption of the rays in the chamber walls. It plays a rôle mainly when using softer rays which are partly prevented from entering the chamber. The other influence consists in the effect caused by the

scattered rays from the chamber wall. This effect becomes particularly important when harder rays are used, and causes additional ionization. To investigate these effects we always constructed our chambers with exactly the same thickness of the walls, i.e., 0.5 mm., then we slipped over the chamber closely fitting caps of the same material, which increased the thickness. Thus we obtained a curve of the ionization current when employing various thicknesses of chamber walls. For soft rays and heavy materials this curve becomes a straight line on logarithmic paper. We can then easily extrapolate the value of ionization for a wall of zero thickness which would be the same value as air. For harder rays and with lighter materials the influence of the thickness of the chamber walls can be studied in the same manner, but the results are not so simple as by using soft rays. This is illustrated by Figure 2. Here the ionization in a small chamber of bakelite is plotted against the thickness of the walls for different qualities of rays. Curve "a" denotes the hardest and Curve "d" the softest rays. There is always a slight ascent of the curves at first, but then they drop, and, for a determined thickness, at every hardness they reach the same value as for a thickness of zero. This means that when the material of the chamber is correct, in order to give the real air ionization there is nevertheless a dependence on the quality of the rays. This can be avoided only by a subsequent correction of the measured ionization current or by extrapolating to the thickness of zero. Thus we may obtain an ideal small chamber, which produces the true air ionization for all kinds of X-rays, independent of the hardness.

By many experiments we succeeded in finding, among other things, a small chamber which gave all of the qualities which we required. Figure 3 illustrates its construction. It was made of bakelite 1 mm. thick

and covered inside with a coating of magnesium and carbon powder of a suitable concentration. It seemed to be impossible to calculate this concentration. We could determine it only by comparison with our

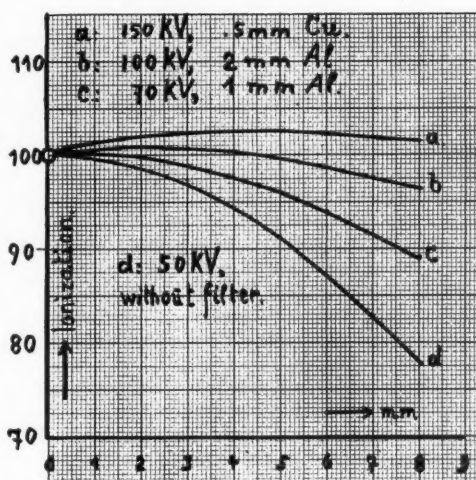


Fig. 2.

standard ionization chamber when using different qualities of radiation. After having determined the wall corrections for all radiation qualities employed, we tried to determine the Solomon X-ray unit with this chamber. For this purpose we used a radium preparation of 42.52 mg. radium element, in a small glass tube about 3.5 mm. in diameter and 20 mm. in length. This we placed on a block of lead with an excavation of suitable form on top. We covered the preparation with 0.5 mm. platinum, as prescribed in the definition of the Solomon

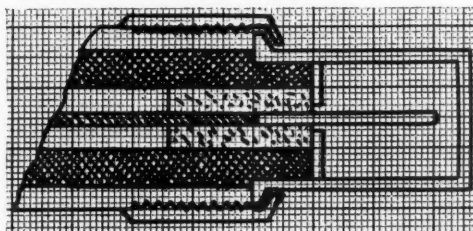


Fig. 3. Small chamber for determination of R-unit.

unit. At first we investigated the influence of different geometrical arrangements of the preparation and the chamber. We put the preparation under the chamber at a distance of about 20 mm. from axis to axis, so that both axes were parallel. In order to see if the ionization so produced really came from the chamber and whether or not there was any undesirable ionization in the other parts of the apparatus, as, for example, in the holder of the chamber or in the electrometer itself, we removed the chamber and the inner electrode from the holder and covered the opening in the front of the insulator with a small sheet of paper; thus the volume of the chamber became zero. The remaining ionization must be attributed to other volumes and must be subtracted when calculating the results. In this manner all measurements which follow were corrected.

Now we displaced the preparation sideways and also in the direction of the axis by keeping it in its plane in order to find the position which gave the maximum ionization inside the chamber. This position was accepted as the correct one. Now only the correct distance between the preparation and the chamber remained to be determined. Solomon prescribes that it shall be 2 centimeters from axis to axis. It is, however, difficult to determine exactly such a short distance between two objects which have the same size. Therefore, we tried to obtain our end in the following way: We put the lead block, with our radium preparation, on a stand which could be displaced vertically. An arbitrary position of the table was designated as zero and any difference was always measured against this position. The inverse squares of these differences were plotted against the ionization in the chamber. In this way we obtained a curve which was nearly a straight line but did not go through zero on account of the zero point being chosen arbitrarily. There was, however,

another point where the curve cut the abscissa, and that point must be the real zero point from which all distances should be taken.

At a distance of 2 centimeters, as prescribed by Solomon, our electrometer ran over seventy parts of the scale when irradiated with 42.51 mg. of radium by filtering with 0.5 mm. of platinum in 38.4 sec., and, therefore, with 1 gram of radium 1.63 sec. would be required. A comparison with our compressed air chamber showed that this rate of discharge of the electrometer means a dose of 0.72 *R* (German). From this we obtain the equation—

$$\begin{aligned} 1.63 \text{ } R \text{ (Solomon)} &= 0.72 \text{ } R \text{ (German)} \text{ or} \\ 1 \text{ } R \text{ (Solomon)} &= 0.442 \text{ } R \text{ (German)} \text{ and} \\ 1 \text{ } R \text{ (German)} &= 2.26 \text{ } R \text{ (Solomon)}. \end{aligned}$$

Solomon had already proposed that the distance of 2 centimeters, which he had prescribed in the definition of his unit, should be changed to such a value that the two units, the Solomon unit and the German unit, would become identical. From the numbers given above we can calculate the distance at which this would occur. It is simply that distance at which the radium gives an ionization 2.26 times more than at 2 centimeters. Therefore—

$$\begin{aligned} 1:2.26 &= \frac{1}{2^2} : \frac{1}{x^2} = x^2:4 \\ x^2 &= 1.78. \\ x &= 1.33 \text{ cm.} \end{aligned}$$

This figure, however, must be regarded as a preliminary result, since our investigations are not fully completed. We may now word a definition of Solomon's unit, which makes this unit the same as the German unit, as follows: "One roentgen is that X-ray dose which produces in a small ionization chamber of the Fricke-Glasser type (air-wall chamber), by eliminating the influence of the absorption and scattering of the walls, the same degree of ionization as is given during one second by the Gamma ra-

diation of one gram radium element at a distance of 1.33 cm. from axis to axis by filtering the radium rays through 0.5 mm. of platinum."

This definition is sufficient for an expert to use in determining an unequivocal Solomon *R*-unit as well as the German definition in order to arrive at the same value as is obtained by means of a compressed air chamber or a cask chamber. But the German definition is still necessary, since a comparison with the cask chamber or with the compressed air chamber is our only means of determining whether or not a small chamber is really one of the Fricke-Glasser type. Thus, also, for acceptance of the correct Solomon unit for the absolute determination of the unit, the cask chamber or the compressed air chamber cannot be omitted. Therefore, we believe that, in order to define an absolute unit, there is no better way than to return to the old idea of Villard as was done by the German Roentgen Society and also by the Radiological Society of North America in adopting their standard unit, and we also believe that this should be done for international agreement.

On the other hand, we believe that the method of Solomon is very good for control

and check of practical dosimeters. Glasser recently found that a series of dosimeters from Europe sent to America had changed their sensitivity considerably and this demonstrated impressively that such controls are necessary for the transport of the "roentgen" from the physical laboratory to the treatment room, from one treatment room to another, and finally, for the agreement between different countries of the world. However, if with radium or uranium sufficient controls are made it is not difficult to transport the roentgen units over any distance and there can be unanimity in measuring X-ray doses all over the world.

Note: Recently one of the authors brought over to America dosimeters especially constructed for the comparison of the units. The instruments were calibrated in the Physikalisch-Technische Reichsanstalt in Charlottenburg and checked by uranium-oxide ionization standards. With these instruments the German *R*-unit was compared with the *R*-unit used by Glasser in Cleveland and with the *R*-unit used by Duane in Cambridge, Mass. The measurements, which later will be published in detail, did not give any difference of practical importance between the units.

THE EPILATION AND THE ERYTHEMA DOSE¹

A COMPARISON OF FILTERED AND UNFILTERED ROENTGEN RAY

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THE particular problem considered in this paper is the relation between the hardness of roentgen rays and their biologic effect. Is quality important solely for its effect upon the distribution of the radiation in the tissues (penetration and scattering), or does a change of quality produce a change of biologic effect with unit dosage?

Fricke and Petersen (1) showed that radiation $\lambda = 0.75 \text{ \AA}$ has within 2 per cent the same effect on oxyhemoglobin solutions as radiation $\lambda = 0.248 \text{ \AA}$, when one measures the amounts applied with a standard air ionization chamber, obviating all wall effect and utilizing the whole of the secondary electron emission from the air irradiated (according to the requirements of Behnken (2) for his *R*-unit). But Glasser and Meyer (3) (4) found erythema dose markedly dependent on the wave length, more than double the amount of hard ray than of soft being required. They worked down to effective wave lengths of about 0.11 \AA .

For a further study of this question we chose epilation as a precisely measurable

biologic effect. The erythema readings were done for completeness, but, of course, contain a larger factor of personal judgment.

PRODUCTION AND MEASUREMENT OF ROENTGEN RAY

We used interrupterless transformers with valve tube rectification, Coolidge 200,000 volt tube, enclosed in a drum lined with 6 mm. lead (5).

Dosage was measured in *R*-units, as defined by Behnken (2). The arrangement of tube, tube shield, diaphragms, and all-air ionization chamber is shown in Figure 1. We were careful not to use the series of aligned lead diaphragm openings which has been described by some workers. Such a series of diaphragms allows only the rays from the focal spot to produce ionization in the measuring chamber, but when the patient is being treated, radiation from parts other than the focal spot reaches the skin. By the simpler method of diaphragming shown in Figure 1, most of the stem radiation is included in the measurement. Not all can be included, for, even with the very large chamber which we used, wall effect can be avoided only by cutting off a part of the stem radiation with the first diaphragm. The use of a galvanometer instead of an electrometer to measure the ionization current minimizes insulation difficulties and leaves the guard plates at the same potential as the galvanometer plate, within 0.00006 volts, removing the uncertainty of changing capacitance effects.

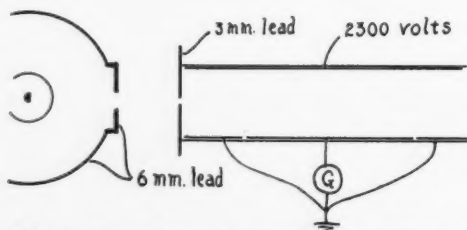


Fig. 1. Arrangement for measurement of roentgen ray beam in *R*-units. The plates are 25 cm. apart. The galvanometer plate is 60 cm. long and the guard plates are each 20 cm. long.

¹Read before the Radiological Society of North America, at the Thirteenth Annual Meeting, at New Orleans, Nov. 28, 1927.

We used roentgen ray of two qualities:

I. Unfiltered

Potential 100 K.V. (crest value as measured with 12.5 cm. spheres)

Current 5 ma.

Coefficient of absorption in aluminum 4.28 (corresponding to half absorption layer of 0.16 cm. and effective wave length of 0.45\AA).

II. Filtered 0.5 mm. copper plus 1.0 mm. aluminum

Potential 190 K.V. (crest value, as measured with 12.5 cm. spheres)

Current 5 ma.

Coefficient of absorption in aluminum 0.598 (corresponding to half absorption layer of 1.16 cm. and effective wave length of 0.17\AA).

The outputs, unfiltered and filtered, were determined at the beginning of the experiment. With the unfiltered beam we relied for constancy of output upon the use of the same tube, under the same potential, and

with the same load. With the filtered beam we assured ourselves of the constancy of output by means of a small brass ionization chamber built into the tube shield. The tube load was varied slightly during the exposures, keeping the ionization current from this chamber at the same value as during the measurement by the all-air ionization chamber (primary standard).

We chose the anterior surfaces of the thighs of five young men (medical students), selected because of an abundance of black hair. Ten round areas were exposed on each thigh.

The left thighs were treated with the unfiltered beam and the right thighs with the filtered beam, doses on each thigh varying in 20 per cent steps from 1600 R down to 215 R, thus:

1280—0	o—1600
820—0	o—1025
525—0	o—655
335—0	o—420
215—0	o—270

The areas treated were 2.5 cm. in diameter, except the ones receiving 1600 R, which were only 1 cm. in diameter.

Epilation was recorded as percentage of hairs out of each area treated (estimated, not accurately counted). Erythema was also noted, and varied from faintest perceptible to rather angry dark red.

Appearance time of epilation was from three to four weeks without definite difference between filtered and unfiltered areas.

For the same case the degree of epilation was practically the same for filtered and for unfiltered ray, but the 50 per cent epilation dose varied from 420 R to 1600 R among the five cases. Complete epilation of body hair was not always obtained, even with doses which produced a bright erythema. (In the scalp, 450 R applied to a large area has produced complete epilation.)

Erythema also was about the same for

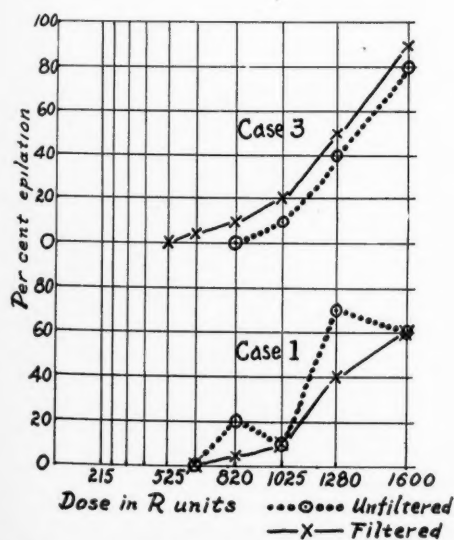


Fig. 2. Degree of epilation attained in six weeks with different doses.

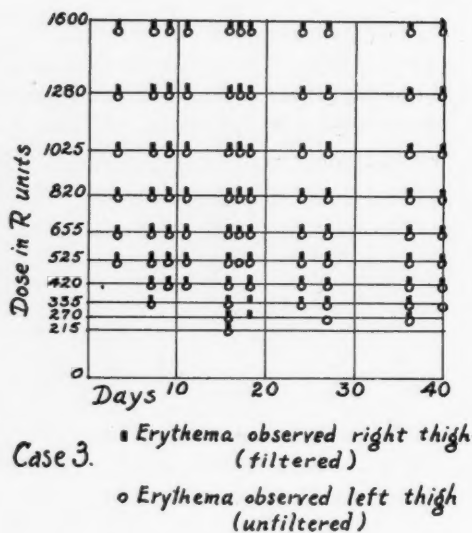


Fig. 3. Erythema observations in a typical case. The number of reddened spots on each thigh is shown for each day of observation. Note that for some of the lower dosages erythema fluctuated from day to day. On the sixteenth day minimum erythema appeared on the right thigh for 215 R, but on the next day only for 655 R. It reappeared on the eighteenth day down to 270 R. For the majority of observations minimum erythema appeared for the same dose on each thigh. But note that on three occasions erythema appeared for a smaller dose of unfiltered than of filtered ray, while on one occasion the opposite was observed.

filtered as for unfiltered ray in any case, some reacting a little more vigorously for one, some for the other (see Figs. 3 and 4), but there was a marked difference in the degree with which the different subjects reacted to the heavier doses (1600 and 1280 R). Subject 2, who showed 100 per cent epilation at 1600 R and visible redness down to 215 R, developed by the fourth week marked swelling of the upper three areas on each thigh, especially about the hair follicles, and a week later rather severe soreness of those areas, while Subject 3, who received 80 or 90 per cent epilation at 1600 R and who showed visible erythema down to 215 R, developed neither soreness nor follicular swelling at any time. There was also remarkable variation in erythema

from day to day in two cases. This is well shown in Figure 3.

DISCUSSION

The roentgen dose delivered to a surface (which we have recorded in R-units) is augmented in every case by back-scattering from the mass of material radiated. This effect is greater for hard than for soft rays, but its magnitude is a disputed matter. It is negligible for very small areas, and, we believe, quite unimportant for the 2.5 cm. areas which we used in this experiment. When, however, we attempt to correlate the results of this experiment with the doses given in everyday practice, this matter of back-scattering becomes very important.

For the past five years our "cancer dose," when applied to large areas (500 sq. cm. or larger) has been 750 R as measured without back-scattering. (Fortunately, the ionization chamber which we have been using as an arbitrary standard for these five years has been preserved, enabling us to recalculate our former doses in terms of R.) For over a year we have been applying doses of unfiltered ray (130 K.V.) larger than 2,000 R to warts and epitheliomata up to 1 cm. in diameter, without producing vesication.

One cannot help being impressed by the tremendous range of dosage between that which produces the faintest perceptible erythema and that which is required to produce a second-degree burn. Ten times the minimum erythema dose may still not produce vesication. At least, this is true for small areas. No wonder investigators cannot agree as to the size of the "erythema dose" in physical units.

McKee's (7) formula for skin dosage, unfiltered, is:

$$1 \text{ skin dose} = \frac{\text{spark gap in inches} \times \text{ma.} \times \text{minutes}}{\text{distance} \times \text{distance (in inches)}} = 36/64$$

For one of our machines this amounts to about 200 R in the beam, which for a large



Fig. 4. Appearance of Subjects 2 and 4 five weeks after administration of varying doses of filtered (right thighs) and unfiltered (left thighs) roentgen ray. Due to differences of lighting, the photograph of Subject 4 exaggerates the reactions on the left thigh, which actually amounted to only about 20 per cent more than those on the right.

area (maximum scattering) would be between 280 *R* (Holthusen, 8) and 400 *R* (extrapolation of results of Failla and Quimby, 6).

CONCLUSIONS

Neither epilation nor skin erythema suffices to define X-ray dosage with satisfactory precision.

We have discovered no difference in the epilation or erythema produced by equal doses (in *R*-units) of hard (λ -eff. 0.17 Å) and soft (λ -eff. 0.45 Å) roentgen rays.

The "maximum safe dose" is several times the minimum erythema dose.

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THE DEMONSTRATION OF THE STANDARDIZATION OF THE ROENTGEN RAY DOSAGE¹

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FOR the purpose of demonstrating the standardization of the X-ray dosage by showing certain methods which are in use at the present time, we have prepared an exhibit by which the various methods may be explained so that they can be readily understood.

Since the problem of the standardization of the X-ray dosage may be divided into four parts, we have also made four divisions of the demonstration.

A.—THE THEORETICAL DEFINITION OF THE ROENTGEN DOSE UNIT

The roentgen dose unit as variously defined is shown in Figure 1. It is found that the absolute unit of the roentgen ray dose, the *R*- or the *e*-unit as defined by Villard in 1908, by Friedrich and Duane in 1918, and by Behnken in 1924, is the same unit as that of Fricke and Glasser as well as that of Solomon, if the latter's definition is slightly modified. These definitions, therefore, may be used in formulating a definition for an international standard unit of roentgen ray dosage.

B.—THE EXPERIMENTAL DETERMINATION OF THE ROENTGEN DOSE UNIT IN THE STANDARDIZATION LABORATORY

This process is illustrated in Figure 2. The unit is determined experimentally according to the text, as follows:

- I. By the compressed-air chamber.
- II. By the large air-ionization chamber. (This instrument is used only to determine the standard *R*-unit and to calibrate and to standardize all types of dosimeters.) The

roentgen ray beam from the focus *F* (see Fig. 3), passing through the lead diaphragm *D*₁, *D*₂, *D*₃, and *D*₄ ionizes the air inside the large chamber. The measuring electrode *E*₁ is connected to an electrometer system *M*. This electrode carries a potential of -200 volts which are supplied by the battery system *B*₁, *B*₂, and *B*₃. *E*₃ has a potential of +1,500 volts, which are furnished by a D.C. generator (*H*). The effective air volume is that included between *E*₁ and *E*₃. The electrodes designated as *E*₂ are guard electrodes.

For the given electrical factors the number of ions formed in the effective air volume is measured by observing the discharge time of the electrometer. The measured dose in roentgen units per minute is given by this formula:

$$\frac{\text{Capacity in cm.} \times \text{volt sensitivity in volts}}{5 \times \text{eff. air volume in c.cm.} \times \text{discharge time in sec.}} R\text{-units per min.}$$

The capacity of the total measuring system is measured by means of a capacity bridge and a calibrated condenser. The volt sensitivity of the total system is measured by means of the test battery *B*₁ and the calibrated voltmeter *V*₁. The effective air volume is determined from the diameter of the diaphragm *D*₃, the length of the electrode *E*₁ and the focal distance. The discharge time of the electrometer is measured by a stop watch. Temperature and pressure readings are taken. Tests are necessary in order to determine that the setting of the diaphragm is sufficiently accurate, that a saturation current is present, and that there is sufficient distance between the electrodes (see Fig. 2).²

¹Presented at the Thirteenth Annual meeting of the Radiological Society of North America at New Orleans, La., Nov. 28-Dec. 2, 1927.

²For a detailed description see "The Standardization of the Roentgen Ray Dose," Am. Jour. Roentgenol. and Rad. Ther., 1928, XIX, 47.

THEORETICAL DEFINITION of the "ROENTGEN" DOSE UNIT

I

THE ABSOLUTE UNIT of the ROENTGEN RAY DOSE - ONE "ROENTGEN" - is OBTAINED from that ROENTGEN RAY ENERGY WHICH, WHEN the SECONDARY ELECTRONS ARE FULLY UTILIZED and SECONDARY RADIATION from the WALL of the CHAMBER IS AVOIDED, UNDER NORMAL CONDITIONS (18°C and 760mm.Hg), PRODUCES IN ONE CUBIC CENTIMETER of ATMOSPHERIC AIR SUCH A DEGREE of CONDUCTIVITY that the QUANTITY of ELECTRICITY MEASURED by SATURATION ~ CURRENT EQUALS ONE ELECTROSTATIC UNIT.

Villard (1908)

Friedrich/Duane (1918)

Behnken (1924)

II

THE STANDARD UNIT of the ROENTGEN RAY DOSE - ONE ROENTGEN - IS THAT DOSE WHICH UNDER NORMAL CONDITIONS PRODUCES by SATURATION an IONIZATION of ONE ELECTROSTATIC UNIT in a VOLUME of ONE CUBIC CENTIMETER of ATMOSPHERIC AIR, THIS CUBIC CENTIMETER of ATMOSPHERIC AIR BEING COMPLETELY SURROUNDED by a SUBSTANCE WHICH HAS the SAME EFFECTIVE ATOMIC NUMBER AS ATMOSPHERIC AIR (7.69)

Fricke and Glasser (1924)

III

THE ABSOLUTE UNIT of the ROENTGEN RAY DOSE - ONE ROENTGEN - IS THAT INTENSITY of RADIATION WHICH UNDER NORMAL CONDITIONS and WHEN FILTERED with $\frac{1}{2}$ mm. of PLATINUM PRODUCES the SAME AMOUNT of IONIZATION PER SECOND AS ONE GRAM of RADIUM ELEMENT at a DISTANCE of 14 cm. FROM the AXIS of the AIR WALL IONIZATION CHAMBER. THE QUANTITY of RADIATION is GIVEN by the RADIATION INTENSITY EXPRESSED in "ROENTGEN" PER SECOND, MULTIPLIED by the TIME of APPLICATION

Solomon (modified definition) 1922

THE
UNITS AS
DESCRIBED by THESE
THREE DEFINITIONS ARE IDENTICAL
THUS THIS ROENTGEN UNIT MAY SERVE
as A STANDARD INTERNATIONAL ~
UNIT of the ROENTGEN RAY DOSE.

Fig. 1. See Part A.

EXPERIMENTAL DETERMINATION of the "ROENTGEN" DOSE UNIT in the STANDARDIZATION LABORATORY

I By the COMPRESSED AIR CHAMBER (SEE BENNKEN)

II By the LARGE AIR IONIZATION CHAMBER

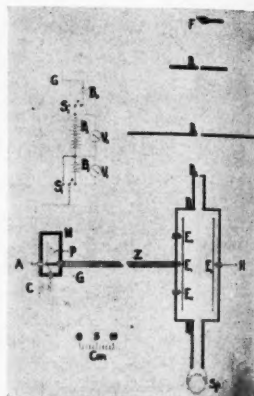
THE ROENTGEN RAY BEAM from the FOCUS F, PASSING THRU the LEAD DIAPHRAGMS D₁, D₂, D₃ and D₄ IONIZES the AIR INSIDE the LARGE CHAMBER. THE MEASURING ELECTRODE E₁ is CONNECTED to an ELECTROMETER SYSTEM M. This ELECTRODE CARRIES a POTENTIAL of -200 VOLTS, SUPPLIED by the BATTERY SYSTEM B₁, B₂ and B₃. E₂ has a POTENTIAL of +1500 VOLTS, FURNISHED by a D.C. GENERATOR. THE EFFECTIVE AIR VOLUME is that INCLUDED BETWEEN E₁ and E₂. THE ELECTRODES DESIGNATED E₃ are GUARD ELECTRODES.

For the GIVEN ELECTRICAL FACTORS the NUMBER of IONS formed in the EFFECTIVE AIR VOLUME is MEASURED by OBSERVING the DISCHARGE TIME of the ELECTROMETER. THE MEASURED DOSE in "ROENTGEN"-UNITS PER MINUTE is GIVEN by the

$$\text{FORMULA:} \quad \frac{\text{CAPACITY} \times \text{VOLT SENSITIVITY}}{\text{in cm.} \times \text{in volt}} \times \frac{\text{EFFECTIVE AIR VOLUME IN CC.} \times \text{DISCHARGE TIME IN SEC.}}{\text{ROENTGEN PER MIN.}}$$

THE CAPACITY of the TOTAL MEASURING SYSTEM is MEASURED by MEANS of a CAPACITY BRIDGE and a CALIBRATED CONDENSER. THE VOLT SENSITIVITY of the TOTAL SYSTEM is MEASURED by MEANS of the TEST BATTERY B₁ and the CALIBRATED VOLTMETER V. THE EFFECTIVE AIR VOLUME is DETERMINED from the DIAMETER of the DIAPHRAGM D₂, the LENGTH of the ELECTRODE E₁, and the FOCAL DISTANCE.

THE DISCHARGE TIME of the ELECTROMETER is MEASURED with a STOP WATCH. TEMPERATURE and PRESSURE READINGS are TAKEN. TESTS to DETERMINE that the SETTING of the DIAPHRAGMS is SUFFICIENTLY ACCURATE that a SATURATION CURRENT is PRESENT and that there is a SUFFICIENT DISTANCE BETWEEN ELECTRODES are NECESSARY.



TEST for ACCURATE SETTING of DIAPHRAGMS
a-d. Accurate screening
b. D₂ omitted
c. D₂ and D₃ omitted



TEST for SATURATION CURRENT



TEST for SUFFICIENT DISTANCE of ELECTRODES

III. By MEANS of the "AIR WALL" CHAMBER. THE AIR VOLUME in the FORMULA GIVEN ABOVE UNDER II can be DETERMINED by MEANS of an AIR WALL CHAMBER 1cc. in VOLUME as DEFINED in A, II. This CHAMBER thus PERMITS the DETERMINATION of the "ROENTGEN" UNIT; IT REGISTERS the UNIT INDEPENDENTLY of the RADIATION QUALITY (see EVOLUTION of the IONIZATION CHAMBER); and IT SERVES to CONNECT the DEFINITION A, III of the "ROENTGEN" with DEFINITION A, II and A, I.

Fig. 2. See Part B, Paragraph II.

III. By the air-wall chamber. The air volume in the preceding formula (Section II) can be determined by means of an air-wall chamber 1 c.c. in volume (see Fig. 1, II). This chamber thus serves three purposes: (1) It permits the determination of the roentgen unit; (2) it registers the unit irrespective of the radiation quality (see evolution of the ionization chamber), and (3) it correlates the modified Solomon

definition of the roentgen unit (Fig. 1, III) with the definition in Figure 1, I and II.

C.—THE TRANSFER OF THE ROENTGEN DOSE UNIT FROM THE STANDARDIZATION LABORATORY TO THE TREATMENT ROOM

This procedure is presented in Figure 4. According to the text of this section prac-

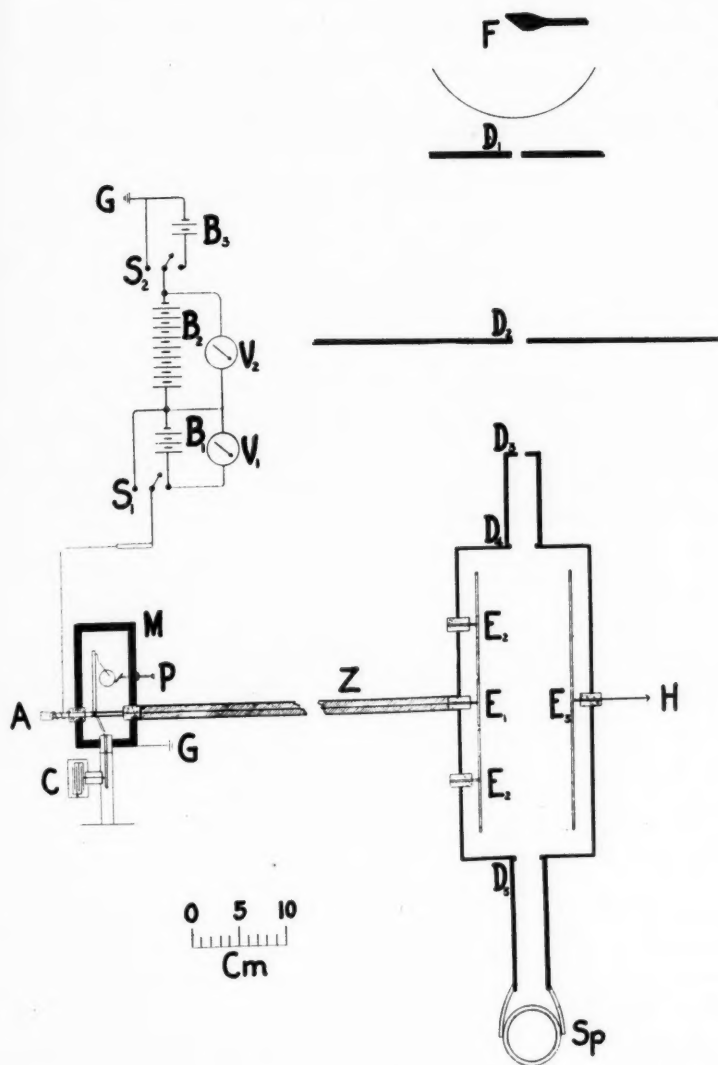


Fig. 3. See Part B, Paragraph II.

tical dosimeters are constructed as follows:

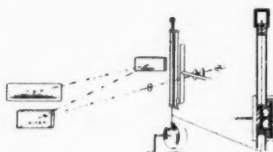
I. *Condenser Dosimeter (Glasser-Seitz).* This dosage instrument (see Fig. 5) consists of two parts: (1) An ionization chamber to which a condenser is attached; (2) a string electrometer.

The method by which this dosimeter is used is as follows: The condenser cham-

ber (1) is connected to the electrometer (2) and the instrument is charged to a known potential. The condenser chamber section is then separated from the electrometer, and the ionization chamber is placed in the field of radiation, as, for instance, on a patient. Ionization takes place in the chamber, and under the influence of radia-

TRANSFER of the "ROENTGEN" DOSE UNIT from the STANDARDIZATION LABORATORY to the TREATMENT ROOM.

I CONDENSER DOSIMETER (Glasser-Seitz)



THIS dosage instrument consists of two parts. I a SECTION consisting of an IONIZATION CHAMBER to which a CONDENSER is ATTACHED. II a STRING ELECTROMETER. The METHOD WHEREBY THIS DOSIMETER is USED is as FOLLOWS. The CONDENSER-CHAMBER SECTION (I) is CONNECTED to the ELECTROMETER (II) and the INSTRUMENT is CHARGED to a KNOWN POTENTIAL. SECTION (I) is then SEPARATED from the ELECTROMETER; the IONIZATION CHAMBER is PLACED in the FIELD of RADIATION, as for INSTANCE on a PATIENT. IONIZATION TAKES PLACE in the CHAMBER and UNDER the INFLUENCE of the RADIATION the CHARGE of the CONDENSER is PARTIALLY LOST. AFTER RADIATION for a SPECIFIC TIME the IONIZATION CHAMBER SECTION is REMOVED and AGAIN CONNECTED to the ELECTROMETER. The DOSE which has been APPLIED in the SPECIFIC TIME is MANIFESTED by the LOSS of the ELECTRICAL CHARGE of the CONDENSER which is MEASURED on the SCALE of the ELECTROMETER. This SCALE is CALIBRATED in "ROENTGEN" UNITS.

With this INSTRUMENT the DOSE CAN BE DIRECTLY MEASURED in "ROENTGEN" UNITS for:

- a - VERY SOFT X-RAYS (BUCKY GRENZRAY) with an EXTREMELY THIN WALLED CHAMBER. a
- b - ALL OTHER X-RAYS (THERAPY and RADIOGRAPHY) and the GAMMA RAYS of RADIUM with the AIR WALL CHAMBERS b and c
- c - SCATTERED RAYS (in PROTECTION MEASUREMENTS) with the LARGE CHAMBER a

II ROENTGEN DOSIMETER (Fricke-Glasser)

the AIR WALL CHAMBER, which REGISTERS the R-UNITS INDEPENDENTLY of the RADIATION QUALITY is CONNECTED by a PARTLY FLEXIBLE CABLE to a STRING ELECTROMETER (COURTESY, VICTOREEN INSTR CO., CLEVELAND, OHIO)

III. PROTECTION ELECTROSCOPE.

MEASURES STRAY RADIATION RECEIVED by OPERATOR in "ROENTGEN" per MONTH

Fig. 4. See Part C.

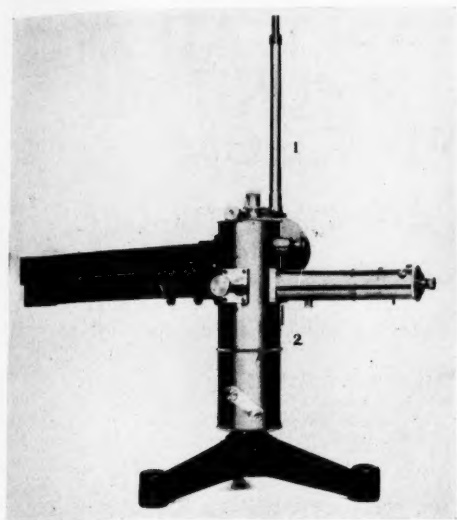


Fig. 5. Condenser Dosimeter (Glasser-Seitz). See Part C, Paragraph I.

tion the charge of the condenser is partially lost. After radiation for a specific time, the ionization chamber section is removed and again connected with the electrometer. The dose which has been applied to the patient in the specific time is manifested by the loss of the electrical charge of the condenser, and is measured on the scale of the electrometer. This scale is calibrated in roentgen units.

With this instrument the dose can be directly measured in roentgen units for the following rays: (1) Very soft X-rays (Bucky-Grenz) with an extremely thin-walled chamber; (2) all other X-rays (therapy and radiography) and the Gamma rays of radium with air-wall chambers; (3) scattered rays in protection measurements with a larger chamber.

II. *Roentgen Dosimeter (Fricke-Glasser)*. The air-wall chamber, which registers the *R*-units irrespective of the radiation quality, is connected to a string electrometer by a partially flexible cable (see Fig. 6).

III. *Protection Electroscope*. This in-

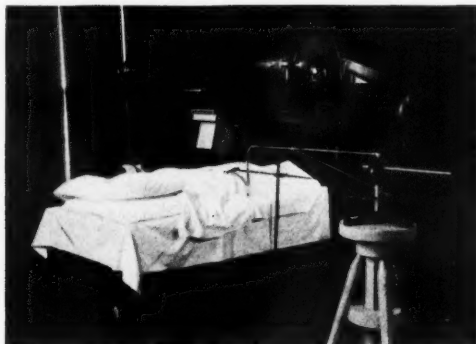


Fig. 6. Roentgen Dosimeter (Fricke-Glasser). See Part C, Paragraph II.

strument measures the stray radiation in *R*-units received per month by the operator.

The sensitivity of all of these instruments is controlled continuously by a radium standard.

D.—THE PRACTICAL APPLICATION OF THE ROENTGEN UNIT IN THE TREATMENT ROOM

The attempt to show the correlation between the skin effect and the physical unit of roentgen ray dosage is illustrated in Figure 7. The accurate measurement of the skin unit can be determined only by measuring directly on the skin of the patient. This can be done only by the use of a small ionization chamber of the air-wall type, which correlates the total direct dose from the focus with the back-scattering from the patient. This measurement of the total dose is accomplished under any condition of size or shape of field or volume or density of tissue, and is, therefore, the actual dose which the skin receives. A curve shows the variation in the time of treatment, which depends upon the area of the field in square centimeters.

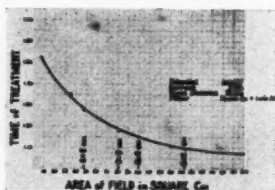
Since all these factors influence the total skin radiation, it is thought that there is considerable variation in the influence upon the human skin of equal doses of X-rays of

PRACTICAL APPLICATION of the "ROENTGEN"-UNIT in the TREATMENT ROOM

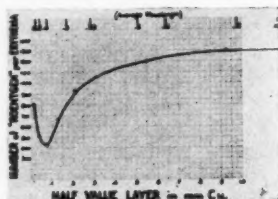
CORRELATION of the SKIN EFFECT with the PHYSICAL "ROENTGEN"-UNIT.

THE NUMBER of "ROENTGEN"-UNITS NECESSARY to OBTAIN an ERYTHEMA DOSE or a SKIN-UNIT DOSE MUST be DETERMINED by MEANS of an AIR WALL CHAMBER, at the PLACE WHERE the REACTION is PRODUCED, i.e., on the SKIN of the PATIENT.

TO CORRELATE the DATA thus OBTAINED with MEASUREMENTS MADE in AIR WITHOUT a SCATTERING MEDIUM, the AMOUNT of BACKSCATTERING from the PATIENT MUST be KNOWN. THIS AMOUNT CAN be READ from the FOLLOWING CURVE.

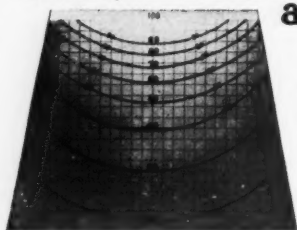


THE NUMBER of "ROENTGEN"-UNITS PER ERYTHEMA DOSE DEPENDS UPON the RADIATION QUALITY WHEN LARGE PORTALS of ENTRY ARE USED. THIS RELATION is ILLUSTRATED in the FOLLOWING CURVE.



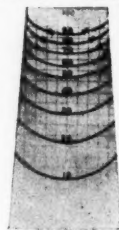
IF SMALL SKIN AREAS or SMALL BIOLOGICAL SPECIMENS are USED, THEN APPARENTLY the EFFECT DOES NOT DEPEND UPON the RADIATION QUALITY.

THE NUMBER of "ROENTGEN"-UNITS RECEIVED WITHIN the BODY for, GIVEN RADIATION CONDITIONS can be OBTAINED from ISODOSAGE CHARTS, TWO EXAMPLES of WHICH are PRESENTED HEREWITH:-



a

VOLTAGE: 200 KV.
FILTER: $\frac{3}{4}$ mm. Cu. + 1 Al.
AREA: 20 x 20 cm.
FOCAL DISTANCE: 50 cm.
HALF VALUE LAYER: 1.1 mm. Cu.



b.

ALL RADIATION CONDITIONS IDENTICAL WITH THOSE on CHART a, but AREA is ONLY 10 x 10 cm.

Fig. 7. See Part D.

different quality. It is true, however, that if the field of radiation is small or if small biological specimens are used, there is apparently little or no variation in the effect of equal doses of radiation of different qualities.

THE PRESENT STATUS OF DOSAGE MEASUREMENT IN GERMANY¹

By HERMANN HOLTHUSEN, M.D., Allgemeines Krankenhaus St. Georg,
HAMBURG, GERMANY

A STANDARDIZATION of dosage measurement seems to be very urgent, principally for two reasons: Firstly, to overcome the dangers of overdosage, which are avoidable only by means of an exact fixing of the dose given; secondly, in order to come to an understanding on the doses which have been given in various countries and at various institutions and have been found to be effective.

Nowadays we are able to state that the suspicion still shown until recently on the part of competent persons against physical dosage measurement by ionization is unfounded. The standardization dosage measurement according to the ionization method is not only reliable but also simple. I should like to stress this latter point particularly in order to combat the assertion that the ionization measurement of X-rays may be successfully handled only by experts, as, for instance, by medical men who have specialized in physics.

The standardization of dosage measurement has been developed on the basis of ionization measurement of the air.

The choice of measuring the ionization effect of the X-rays in air was carried out for metro-technical reasons. But it has been shown that the ionization method is, on principle, superior to the other well known methods of X-ray measurement. It is true that, if the object of the X-ray dosage were to measure an equivalent for the radial energy effected in a volume element of tissue, it would appear justified, rather, to start from the effect produced in the volume unity of water. This was the path taken

by Dauvillier, who took as a unit of X-ray effects the X-ray energy absorbed by a cubic centimeter of water. But even Dauvillier could not ascertain this quantity directly by means of a measurement in water: he also started with an ionization measurement in air and recalculated with regard to water.

The fundamental advantage in the use of an X-ray reaction taking place in the air lies in the fact that its absorption runs completely parallel to the absorption in the tissues through the whole range of technically employed X-rays. On the contrary, this is not the case with regard to the other well known forms of reaction to X-rays, as, for instance, photographic emulsions, the Sabouraud tablet or the selenium cell. The parallelism of the absorption of roentgen rays between the reagent and the tissue is, if not sufficient, at any rate a necessary presumption for the relations which have been ascertained for a certain voltage and filtration, being valid also for other qualities of rays.

Since we have learned to take into consideration the scattering-absorption, we understand that this holds good only for substances of the same effective atomic number. In the case of bodies of different atomic weights the percentage of scattering-absorption in the total absorption varies and becomes less; the more pure absorption increases with the atomic weight.

Bodies with a higher effective atomic number than air show in the field of hard rays an effect decreasing with their hardness, as compared with the ionization effect in the air. This is true in comparing the ionization effect of gases of higher atomic weight with the ionization effect of air (Dognon). Such is also the case in the photochemical

¹Read before the Radiological Society of North America, at the Thirteenth Annual Meeting, at New Orleans, Nov. 28, 1927.

effect of X-rays on liquids, as, for instance, in Fricke's trials with solutions of hemoglobin and its transmutation into methemoglobin. His investigations show that the hemoglobin solution, the effective atomic

If the studies on this subject and especially on the question regarding the erythema effect of X-rays of various wave lengths have, until now, led to very different results, they are, above all, the expression of the great

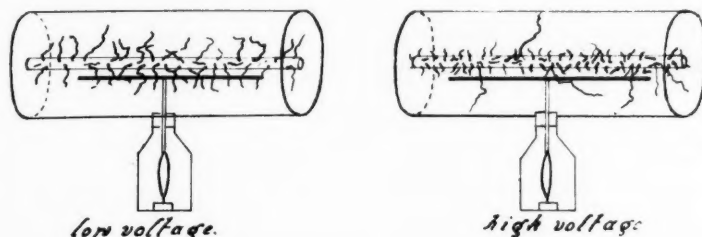


Fig. 1. Paths of photo- and recoil-electrons.

number of which was increased by addition of salt, was less sensitive when exposed to hard rays than the watery hemoglobin solution. Fricke has proved with these experiments that the photochemical effect of X-rays on watery solutions ran parallel to the ionization in air within a range of effective wave lengths between 0.75 and 2.48 Å.U. He made his measurements not only with an oxyhemoglobin solution and his transformation into methemoglobin, but also with the titrimetrically measured reduction of ferrosulphate into ferrisulphate.

This question, which is so important for therapeutic practice, as to whether the therapeutic effect in the body runs parallel to the ionization effect in any range of different wave lengths, is not decided by these experiments. It is not impossible that special conditions rule for the living tissue, because we have to deal with a structured medium. It is, however, probable, according to our present-day knowledge, that the primary effect on living tissue is of a photochemical nature. During the last few years very careful investigations have been made, rendering it probable that the biological action of X-rays at different wave lengths also runs parallel to the ionization effect in air.

technical difficulties which are opposed to a reliable measurement of air ionization.

Only if we consider the ionization effect in a volume element which is in equilibrium with its surroundings, are we entitled to set into parallelity the air reactions and the tissue effects independently of the quality of the rays. Equilibrium exists in a volume element only when it is not bounded by any walls but is situated in the center of a mass of air of the same properties of constitution and pressure. If the measurement is carried out in a cubic centimeter of air, which is enclosed by metal walls, the ionization effect, caused by the presence of X-rays, would originate for the greater part from electrons which are not formed in the air in connection with the absorption of the rays, but originate out of the chamber walls. However, the electronic radiation from surfaces, and especially from metallic surfaces, follows laws which vary greatly from those governing the absorption in a volume of air.

The demands for a measurement of a pure ionization effect of the air under conditions which enable the electrons formed in the radiated volume of air to expend all their energy in the radiated volume without being influenced by the effect of the walls,

are very nearly realized by an arrangement shown in Figure 1, which is the plan of a large ionization chamber axially penetrated by a bunch of X-rays. The photo-electrons sent off at their absorption have a range

chamber, in which the inside electrode is arranged somewhat out of the center, so that it cannot be directly struck by the penetrating bundle of rays, the electric field between the charged inside electrode and the

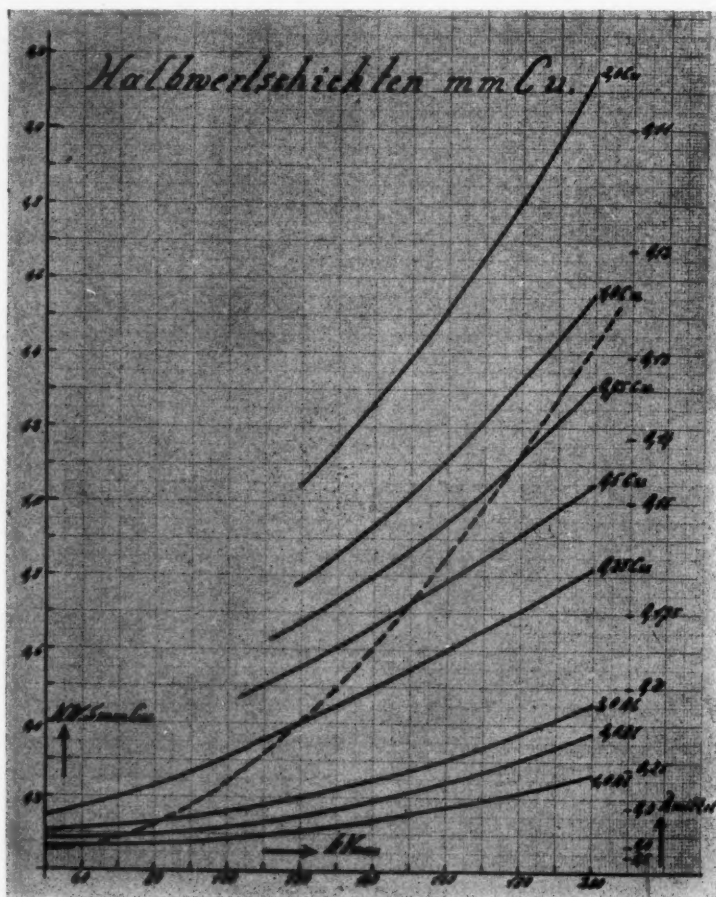


Fig. 2. Half value layers in copper.

corresponding to the voltage of the primary beam. Considering the comparatively long range of the photo-electrons excited by hard rays, it would seem that part of the photo-electrons formed in the air are absorbed by the wall. The investigations of Becker and Holthusen and later on of Fricke and Glasser have proved this to be the case. In this

outside wall of the barrel-shaped chamber is so homogeneous that saturation may be obtained with a relatively small tension, i.e., all the electrons formed are conducted to the inside electrode.

It would seem that the realization of the principle of pure ionization measurement in the air could be attained only by chambers of

very large dimensions. In order to avoid complications arising therefrom, pressure was raised and the range of the photo-electrons thereby diminished. In this manner the Behnken compressed air chamber was invented, in which, by means of a corresponding increase of pressure even the most rapid electrons were fully absorbed inside the chamber. During the last few years it has been recognized that ionization in the case of high voltage is produced in a small amount only by the photo-electrons, but chiefly by recoil-electrons with a very short range. These geometrical conditions of the formation of ions in the case of hard rays explain why it is not necessary, even in the case of hard X-rays, to considerably increase the dimensions of the chamber or to raise the pressure in the chamber, in order to obtain the full effect of ionization.

The standard unit chosen on the basis of this ionization measurement was the amount of X-ray energy which produces a conductivity corresponding to one electrostatic unit, one cubic centimeter of air being irradiated under normal conditions, *i.e.*, at a temperature of 18° and atmospheric pressure.

I have brought over to you an instrument which is constructed according to this principle to serve practical purposes. It was made by Dr. Küstner, in Göttingen, according to the plan which I have just shown you.

The discharge of the electrometer in Küstner's "Eichstandgerät" is constant for the same number of *R*-units in a very long range of wave lengths. This means that by the use of this instrument the *R*-unit is measured according to its definition.

Owing to irregularities of the atmospheric pressure, changes in the tension of the electrometer thread, and a few other reasons, the constancy of the sensitiveness of such instruments is subject to variations that call for control. This control is carried out with the aid of a radium standard which,

brought into the chamber, causes a constantly even ionization.

The use of radium for proving a constant sensitiveness seems to me a very good solution of the problem in question, if its use is limited to this task, for which it is especially suited as a constant source of radiation. The unity itself should be derived from the absolute system of units. By this means a more exact definition of the unit in a physical sense is arrived at, than can be gained on the basis of the γ -radiation of a certain quantity of radium.

In carrying out the measurement of an X-radiation one source of error which is very likely to occur when working with a narrow pencil of rays must be taken into consideration. The effective rays of each therapeutic radiation are composed of the rays coming from the target itself and from its stem. If we measure a bundle of rays that has been screened off in the very neighborhood of the tube, we have to deal only with the radiation of the target. On the other hand, the whole radiation of the tube falls into the measuring chamber, if the radiation is screened off near to the ionization chamber.

Besides the correct screening off, the following rules have to be observed:

1. The chamber must be brought into the direction of the rays. This is effected by sighting the target over two crossed threads, placed in the center of the anterior and posterior walls of the chamber, these walls being made of celon, and transparent.

2. The distance from the target to the anterior wall of the chamber must be measured.

3. The measurement itself consists in noting the lapse of time that is needed by the electrometer thread to pass over a certain number of scale divisions. If several readings are taken and the slope of the electrometer in using the radium standard is noted, the number of *R*-units per minute

at a given distance can be calculated by a very simple formula.

The number of *R*-units per minute at the skin surface is given by the ratio of the lapse of time for the electrometer to run down in connection with the radium and X-radiation, multiplied by the screen factor—which depends upon the size of the opening in the diaphragm and the constants of the instrument—and the square power of the ratio of the distances, wherein the measurement has been made and the irradiation is to be carried out. This calculation may as well be carried out by making use of a base-line table.

The checking up of the effective dose in an X-ray beam at a given distance means the solution of only one problem of dosage measurement. Much has been written about the measurement of the quality of X-rays, and the proper method which may be practically employed in therapeutic institutes. Personally, I am an adherent of the measuring of the absorption and particularly the measuring of the half value layer in copper for therapeutic radiations and in aluminium for radiations in surface therapy. Of all the reasons in favor of measuring the half value layer, let me mention only the practical advantage, arising out of the fact that the measuring of the half value layer can be carried out under the same conditions as dosage. We need only ascertain the thickness of the layer of copper or aluminium which has to be brought into the X-ray beam, in order to double the time for the electrometer to slope. As a close connection exists between the absorption and the wave length, it is possible without any difficulty to change from the half value layer to the effective wave length. Figure 2 shows the alteration of the half value layer with different filters and voltages. The continuous lines show the increase of the half value layer with rising voltage for different filters. The values for the maximum volt-

age were calculated from the shortest wave length out of spectrograms, taken with the Seemann spectrometer. Suppose we have put in a filter of 0.5 mm. Cu. and we measure a half value layer of 0.9 mm. Cu., the tube runs with 175 K.V. A half value layer of 0.3 mm. Cu. behind a filter of 3 mm. Al. corresponds to a voltage of 140 K.V.

Let us consider for a moment the alteration of the penetrating power with the filter at constant voltage. We see that the penetrative power of the radiation rises rapidly with the increase in filtration measured by the thickness of the half value layer. On the other hand, if we consider the alteration of the radiation quality with increasing voltage, keeping in the same filter, we are able to state that the penetrating power rises only very slowly. In any case it increases much more slowly than it should according to the laws of absorption for a homogenic radiation. For a homogenic radiation the change of absorption, and accordingly of the half value layer, goes, as is well known, with the third power of the wave length. It would seem that the degree of homogeneity behind a certain filter becomes more and more incomplete with increasing voltage. Therefrom we have a means of ascertaining how a radiation should be filtered at any voltage, in order to have a constant degree of homogeneity. We have only to demand that the penetrative power of the rays should vary according to the laws of absorption. A curve, corresponding to a variation of the half value layer with the third power of the voltage, connects points of equal homogeneity on the various curves of filtration. For the curve shown in Figure 2 (dotted line) it is assumed that a radiation of 150 K.V. and 0.5 mm. Cu. is sufficiently homogenized.

It may be understood easily that the perpendicular distance of a certain point of a filter curve which has been measured from the "isohomogeneity-curve" is a measure-

ment for the degree of the heterogeneity of the radiation in question, as voltage, filter, half value layer, and degree of homogeneity of the radiation behind the filter are dependent on each other. The voltage and the

physical dosage cannot be based thereon. In order to measure it exactly, we should make use of a very small dosimeter which we should place in the center of the surface of the X-ray beam. In reality we

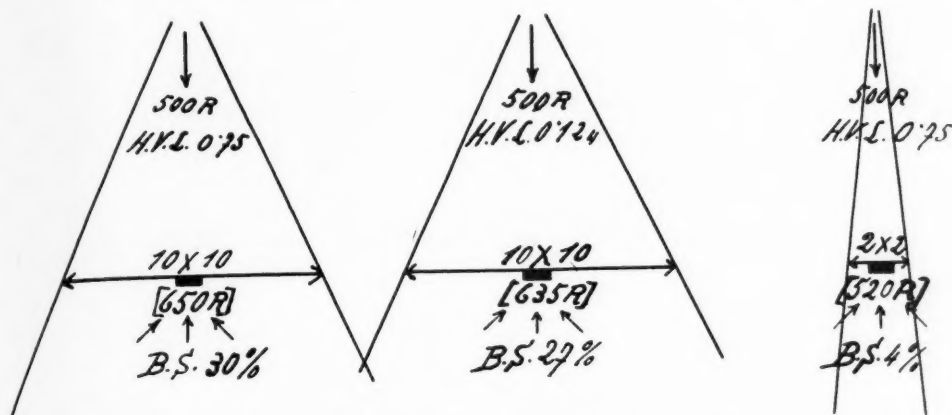


Fig. 3. Influence of field area and back-scattering upon total dose.

degree of homogeneity are fixed by the thickness of the half value layer in connection with a certain filter. This, of course, holds only for a certain type of apparatus; in our case, for continually equal tension.

By means of two simple lines of measurement we have ascertained not only the doses issued in a certain time, but also the quality of the rays, not only with regard to the penetrative power, but also to the degree of inhomogeneity. *All R-values measured by this method refer to the dose, supplied by the radiation in open beams without back-scattering.* In connection with the irradiation of a large area of skin, the dose operating on a certain point of the surface is increased by the amount of back-scattering, which is dependent in the first place on the size of the surface area, in the second place on the quality of the rays (Fig. 3). It is this combined primary radiation and back-scattering which are biologically effective and on which we must base the biological dose. Unfortunately this value cannot be measured with sufficient accuracy, so that

are still unable to measure the sum total of primary radiation and back-scattering by this ideal method, but only approximately with the aid of so-called Fingerhut chambers, which, however, are still too voluminous to suffice for the given task. Nevertheless, the errors which creep into the measurements of back-scattering in the case of an ionization chamber can be calculated. In all three cases (Fig. 3) it is assumed that a dose of 500 R-units has been given.

The dose received by a volume element in the center of the beam at the surface of an area 10×10 cm. and a quality of 0.7 mm. Cu. half value layer amounts under these conditions to 650 R, taking an additional 30 per cent of back-scattering into consideration. In the second example the quality of the rays has been altered, in the third the area. A decrease of the penetrative power of the radiation on to 0.12 mm. Cu. half value layer, as we have it in the case of 80 K.V. and 3.0 mm. Al. filter, diminishes the back-scattering to 27 per cent and therewith the superficial dose to 635 R. The in-

fluence of a decrease of the size to 2×2 cm., as is shown in Example 3, is much more effective. Then the back-scattering has fallen off to 4 per cent, the surface dose amounting to only 520 R-units.²

S.U.D. is not only more comprehensive, but is especially to be recommended, because all measurements of the effective dose in the tissues in R-units heretofore carried out bear a preliminary character.

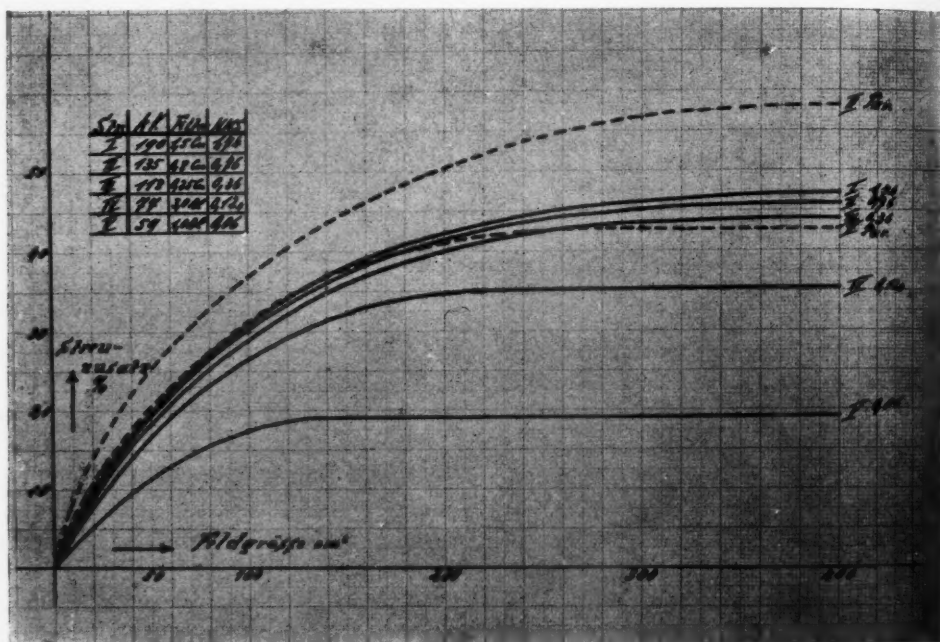


Fig. 4. Back-scattering curves.

We now have to consider the point that different physical doses have to be applied, in order to get the same effective dose on the surface, and that the idea of dosage is employed not only for the amount of X-rays given, but also for the effectual dose in the tissue either on the surface or below it. In order to avoid confusion of these two definitions of the "dose," we in Germany have proposed to limit the measurement of R-units to the dose supplied by the roentgen tube, which dose must be measured without the addition of the back-scattering, and to keep to the idea of S.U.D. as the effective dose in the tissues. The measurement of the biological dosage in fractions of the

How is the effective dose in a surface element of the tissue to be found if we measure the radiation quality only in the open X-ray beam? By *calculation*, under the assumption that the connection between surface area, the quality of the radiation and the back-scattering is known. Curves which give this reaction have been repeatedly measured. The results of our own measurements (Fig. 4) show the well known character of back-scattering curves, *viz.*, rapid increase of back-scattering on small areas and arriving at a maximum on larger areas, which is arrived at the sooner and lies the deeper, the harder is the radiation.

In order to employ these back-scattering measurements in routine work, we plotted

²These figures are taken from our own measurements.

the areas given in square centimeters against the number of *R*-units which must be given to place the S.U.D. in the center of the surface of the field of radiation. The curves include voltages between 190 K.V., 1.5 mm. Cu. (half value layer 1.74 mm. Cu.) and 65 K.V., 1.0 mm. Al. (half value layer 0.06 mm. Cu.). I state expressly that these curves bear only a preliminary character on account of the relative unreliability of their method of measurement. They have been gained in the best way possible and may be looked upon as approaching correctness, considering the general character of the curves. Furthermore, I wish to point out that the connection between a certain number of *R*-units and the S.U.D. under standard conditions had to be fixed in order to draw up the diagram. A calculation by Küstner based upon the experience of a number of large German roentgen institutes which have taken measurements with the Küstner gauging instrument, has shown that 550 *R* with an area of 6×8 cm., and a hard therapeutic radiation correspond to the S.U.D. This result tallies with our own observations. The measurements regarding the amount of the back-scattering on the area above mentioned show that in the surface element in which a reaction corresponding to a S.U.D. must appear, there must have been 675 *R*-units effective. Therefore greatly different quantities of *R*-units are

necessary under various conditions, in order to produce the biological effect of a S.U.D. on the skin.

In drawing up this diagram, we have gone from a second presumption with regard to the influence of the quality of the rays on the biological effect of a certain number of *R*-units on the skin.

We also started with this question, and, in attempting to answer it, we had set ourselves the task of first clearing up the principal questions of ionization measurements. The investigations of our institute have shown that in measuring ionization in *R*-units by the Küstner instrument, a quantity of *R*-units, which has been proved to be non-destructive to the skin with a hard radiation, may also be given without risk in a soft radiation.

In summing up, my intention was to show that the standardization of dosage measurement has not led to complication, but to simplification. The checking up of the radiation quantity and quality is reduced to a few readings taken on an electrometer. Certainly a minimum of physical comprehension has to be presumed if the dosage measurement is supposed to be reliable. Considering the fact that we have to deal with a purely physical agent we ought to admit that this is not an exaggerated claim but a necessity.

CLINICAL AND PHYSICAL INVESTIGATIONS OF THE PROBLEM OF DOSIMETRY IN ROENTGEN THERAPY¹

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THE ideal for which we are striving in dosimetry in roentgen therapy is the establishment and acceptance of a well defined unit which will make any administered dose of roentgen rays reproducible. According to our present knowledge, this unit must be a physical unit because there should be no doubt left in any one's mind that the so-called erythema dose or skin unit dose can not answer the requirements. The logical unit appears to be the roentgen unit as defined by Behnken (1), based on the electrostatic unit. Unfortunately, its absolute measurements done in Berlin and in this country are at variance (Meyer and Glasser, 2, 3), the cause of the discrepancy still being unknown. In practice, however, we can easily work with either one and use the chosen unit as basis for the therapeutic application of roentgen rays.

It is, of course, necessary to correlate this physical unit in some way with the biological effect. In principle there is not much difference which biological dose unit represents the connecting link: erythema dose, tolerance dose, or safe maximum dose. Investigations in this field have been done by a number of clinicians and physicists; the analysis of their work reveals three groups. One finds a definite dependence between the average wave length of the radiation and the number of roentgen units required for the so-called erythema dose. There may be an increase of the primary energy with decreasing wave length (Meyer and Glasser, *loc. cit.*, and others) or just the opposite (Schreus, 4), while one author (Holthusen, 5) recommends the use of the same num-

ber of roentgen units through the entire range of radiation, beginning at 64 K.V., filtered through 6 mm. cardboard, up to 186 K.V., filtered through 1 mm. copper plus 1 mm. aluminum. Our own standpoint regarding that particular question will be set forth in detail in the second chapter of this article. When approaching the subject as a whole, we were confronted by this fact of discrepancy and assumed that there was a relation between penetration of roentgen rays and the number of roentgen units required for the erythema. In this case, and also if the measuring instrument is dependent upon the wave length, it will be necessary to give a quality factor in addition to the amount of energy used in order to make the dose reproducible. Numerous methods have been suggested for expressing the quality or penetration of roentgen rays; they have been briefly reviewed by one of us (Pohle, 6). Suffice it to say that we confined our study to the measurements of the half value layer in copper and aluminum, both by the ionometric and photographic method as compared with the effective wave length according to Duane.

I. QUALITY (PENETRATION OF ROENTGEN RAYS)

As ionization instruments, the Dessauer Electroscopic, the Siemens Dosimeter, and the Wulf Ionometer were available in our laboratory. The electroscopic, which is very simple in construction (Fig. 1), seems to be one of the most reliable instruments for quality measurements, if one only makes sure that it is well focused. Every change in position must be avoided while taking the readings. Because of its large ionization

¹Read by Dr. Pohle before the Radiological Society of North America, at the Thirteenth Annual Meeting, at New Orleans, Nov. 28, 1927.

chamber, it is slightly dependent upon the wave length and lends itself very readily to absorption studies of roentgen rays produced at relatively low voltage. The Siemens Dosimeter is built on the principle of

scope and of the Wulf Ionometer was negligible. Several times the amber insulation of the latter gave us trouble in transit, resulting in an undesirable amount of leakage. Radium checks permitted the necessary cor-

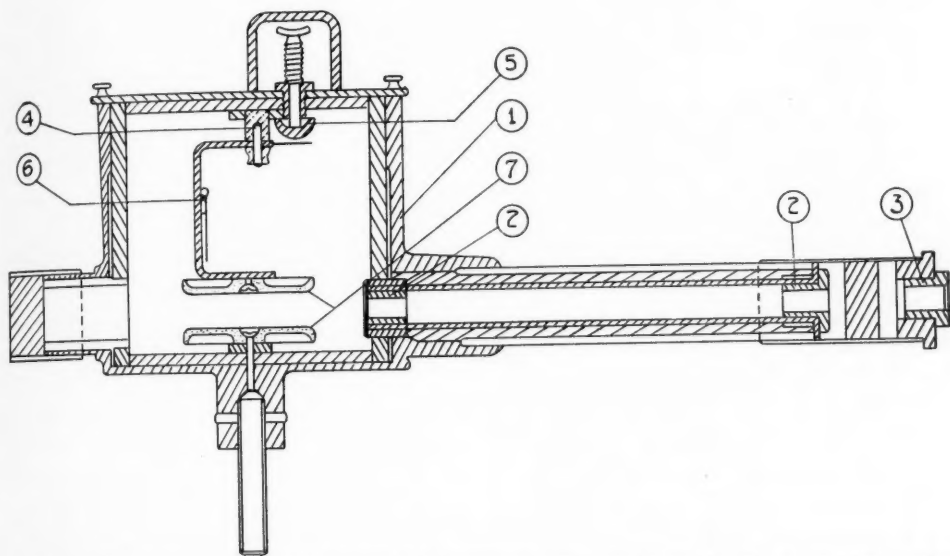


Fig. 1. The electro-scope. Lead housing (1), diaphragm (2), exchangeable diaphragm (3), amber insulation (4), charging button (5), carbon filament (6), carbon plates (7).

an iontoquantimeter; a small ivory ionization chamber² is connected by a highly insulated cable through an amplification device to a galvanometer of ordinary sensitivity. In this way the ionization current can be amplified about one hundred thousand times. A sealed uranium preparation delivering a constant current serves as standard in order to check the sensitivity of the apparatus and thus gives readings of the ionization current in 10^{-10} amperes (Fig. 2).

The Wulf Ionometer consists of a carbon chamber which is connected by a stiff cable to a Wulf string galvanometer, the deflection of which is projected by a magnifying device on a scale. Careful tests convinced us that the natural leakage of the electro-

reactions for the calculation of the dose. Calibration of the Wulf Ionometer against the Siemens Dosimeter, which is controlled by the uranium standard, showed not more than plus or minus 3 per cent change over a period of eleven months. Under normal conditions the natural leakage of the Wulf Ionometer amounted to over thirty minutes for one-tenth part of the scale. It is needless to say that all the required precautions were taken which are called for in measurements of this type, as, for instance, saturation current, perfect ground, and protection of the instrument against stray radiation. While for filtered radiation above a certain minimum penetration, all three instruments showed fair agreement, it was necessary to use the Dessauer Electro-scope alone for tests on unfiltered radiation, particularly below 100 K.V.; at the same time, the photo-

²Recently we had available one of Glocker's chambers, which are independent of the wave length between 60 K.V. and 200 K.V. (See *Strahlentherapie*, 1926, XXIII, 447.)

graphic determination of the half value layers in aluminum and copper following Meyer (7) was done. The results are compiled in Tables I and II. The figures represent the mean values of at least three series of tests

here (Fig. 3). From these we read the half value layer as determined with the ionization method. The logarithms of the intensities are plotted against the filter thickness. It is most convenient to use semi-log paper

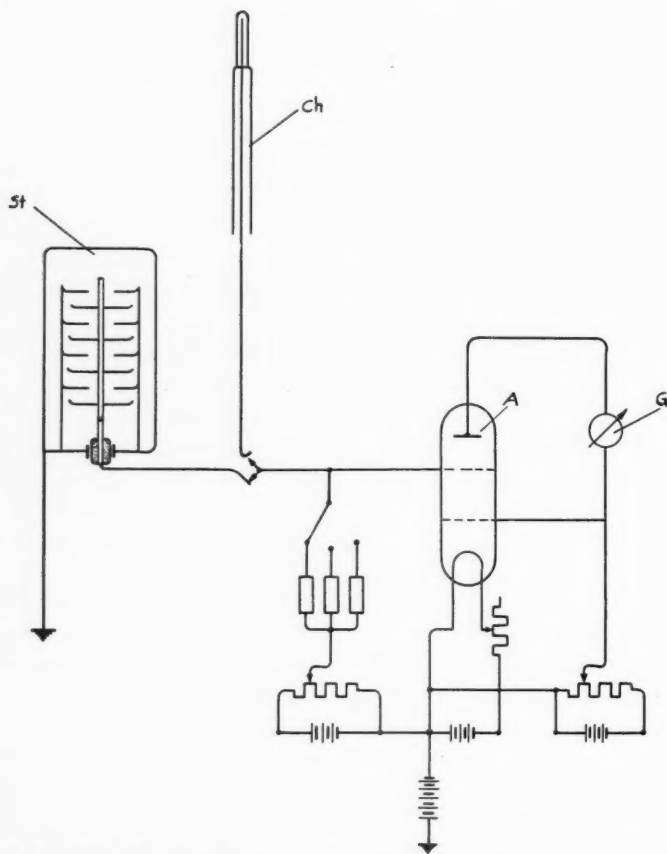


Fig. 2. Schematic circuit of Siemens Dosimeter. Amplifier (A), galvanometer (G), uranium standard (St), ionization chamber (Ch).

taken about one month apart, and the photographic half value layers are averaged from estimations as recorded by three independent observers, on a total of 200 films. For beams of Lambda effective in aluminum higher than 0.4 A. or in copper higher than 0.24 A., the percentage of transmission through either filter is given, because Duane's charts (8) do not contain values for rays of such low penetration. One of the absorption curves may be reproduced

for this purpose. The study of such an absorption curve reveals also the thickness of the "homogeneity filter," *i.e.*, from the point where the curve becomes a straight line, the X-ray beam is practically homogeneous. Extensive investigations of this subject have been published recently by Holthusen and Gollwitzer (9); their data giving the homogeneity filter as well as the half value layer in copper of the various radiations are reprinted in Table III. Our

TABLE I

K.V.	Filter	H.V.L. (Al.)		λ eff. Al. ³
		photo	iono	
60	0	1.25	.4	7.4%
	1	2.0	1.1	18.0%
	2	2.5	1.8	24.3%
	3	2.25	2.1	25.6%
	4	2.25	2.1	26 %
70	0	1.0	.6	10.2%
	1	2.25	1.2	18.6%
	2	2.75	1.8	26.8%
	3	2.75	2.1	30 %
	4	3.0	2.6	.4 A
80	0	1.25	.6	13 %
	1	1.75	1.6	26 %
	2	3.75	2.1	.4 A
	3	3.75	2.6	.38 A
	4	4.0	2.8	.38 A
90	0	2.0	.7	15 %
	1	2.75	1.8	29 %
	2	4.0	2.7	.38 A
	3	3.75	3.0	.37 A
	4	4.0	3.0	.37 A

³Percentage of transmission through 4.0 Al. (For explanation, see text.)

own values are added in parentheses. They agree well enough to be within the error of measuring, not to speak of possible variations due to the use of another type of apparatus and tube. We accept the conclusions of these authors that the half value layer in copper of filtered radiation, the thickness of the filter being known, is an exact way of expressing the penetration of an X-ray beam. From our compilations (Tables I and II), it appears that the absorption curve in copper for potentials above 140 K.V. or in aluminum for lower potentials represents an ideal method of characterizing the quality of roentgen rays. This offers also the half value layer in either material.⁴ Next comes probably the meas-

urement of the effective wave length in aluminum or copper, according to Duane, and as an approximate orientation, the photographic recording of the half value layer in copper and aluminum. The latter checks

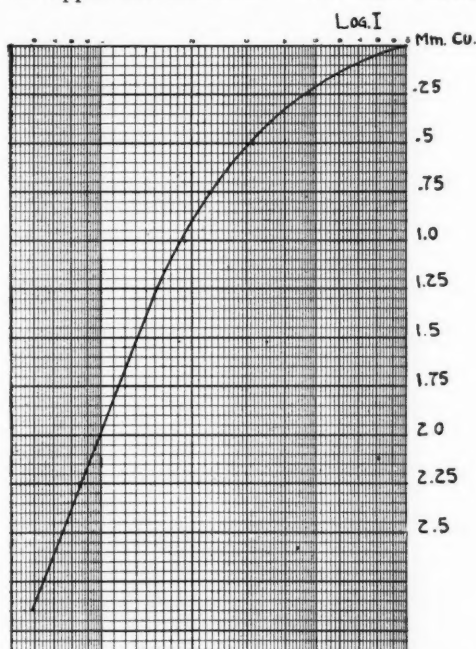


Fig. 3. Absorption curve in copper for 200 K.V., 25 ma. The ordinate gives the filter thickness in mm., the abscissa the logarithms of the respective intensities.

better in the range of short wave length with the ionization method than at lower potentials. We also feel obliged to state that a certain amount of individual variation enters into the estimation of the half value layer on the photographic films.

II. THERAPEUTIC DOSES IN ROENTGEN UNITS

Considerable difficulty is encountered when attempting to connect the physical unit with the biological effect. This is due to the fact that the erythema reaction can not be well enough defined. Numerous investigators agree on that point—we mention only the recent paper by Leddy (10). Our own rather extensive studies have not

⁴The absorption coefficient or the average wave length, according to Mutscheller (See this Journal, 1924, III, 328), may also be derived from that curve.

TABLE II

K. V.	Filter	H.V.L. (Al.)		H.V.L. (Cu.)		Lambda eff.	
		photo	iono	photo	iono	Al.	Cu.
100	0 Al.	1.5	0.9	0.1	.025	18% ^s	—
	1.0	2.5	2.0	.1	—	.4 A	—
	2.0	3.0	2.8	.1	—	.36 A	—
	3.0	5.0+	3.6	.2	—	.34 A	—
	4.0	5.0+	4.0	.2	—	.32 A	—
	0.25 Cu.	9.0	7.5	.3	.32	.24 A	.23 A
110	0 Al.	1.5	.9	.1	—	19.5%	—
	1.0	3.0	2.0	.1	—	.39 A	—
	2.0	4.0	3.2	.1	—	.35 A	—
	3.0	4.5	3.7	.2	—	.33 A	.24 A
	4.0	6.0	3.8	.2	—	.33 A	.24 A
	0.25 Cu.	10.0	8.0	.4	.37	.23 A	.21 A
120	0 Al.	1.0	.9	.1	.035	21%	—
	1.0	3.0	2.4	.1	.08	.39 A	—
	2.0	4.0	3.0	.2	.12	.34 A	—
	3.0	6.0	3.8	.2	.16	.33 A	.24 A
	4.0	6.0	4.2	.3	.22	.31 A	.24 A
	0.25 Cu.	10.0	8.5	.4	.42	.22 A	.20 A
130	0 Al.	2.0	1.4	.1	.04	25%	—
	1.0	3.0	2.5	.2	.08	.37 A	—
	2.0	4.0	3.3	.2	.15	.33 A	.24 A
	3.0	5.0	4.5	.2	.17	.32 A	.24 A
	4.0	6.0	5.0	.3	.21	.30 A	.23 A
	0.25 Cu.	10.0	10.0	.5	.47	.22 A	.19 A
150	0 Al.	1.75	1.3	.1	.06	27.8%	7.7%
	1.0	4.0	3.4	.2	.13	.34 A	.23 A
	2.0	5.0	4.4	.2	.16	.32 A	.22 A
	3.0	6.0	5.4	.3	.2	.29 A	.21 A
	4.0	7.0	5.9	.3	.25	.27 A	.20 A
	0.25 Cu.	12.0	11.0	.6	.62	.18 A	.17 A
200	0.5 Cu.	14	12.0	.65	.8	.156 A	.164 A
	0 Al.	5.0	4.3	.2	.14	—	.22 A
	0.5 Cu.	12-14	17.0	.7	.92	—	.16 A
	1.0 Cu.	15-16	19.0	.8	1.3	—	.138 A

^sPercentage of transmission through 4.0 Al. (For explanation, see text.)

led to different conclusions. No matter whether a tintometer is used to measure the degree of reddening and tanning, or the capillary reaction is followed up by means of the skin microscope, there seems to be too much difference in the individual response, not to speak of the variations in the original color of the skin, to permit exact measurements. The only promising way out of the situation is perhaps the use of the spectrophotometric analysis of the original color of the skin in a large number of nor-

mal individuals, a method suggested by Sheard and Brown (11), followed by an analysis of the erythema and pigmentation.

When approaching the problem of the relation between penetration of roentgen rays and the so-called erythema dose, we thought it best to calibrate a number of machines where this erythema reaction was well studied and the erythema dose based on clinical observations only. The translation of this empirical erythema unit into roentgen units should offer, then, not only data

TABLE III

Kilovolt	Homogeneity	H.V.L. (Cu.)
70	1.0 mm. Al. (3.0 Al.)	0.05 (.058)
80	2.5 mm. Al. (3.0 Al.)	0.085 (.09)
90	4.0 mm. Al.	0.135 (.145)
125 (130)	Approx. 0.25 mm. Cu. (+1.0 Al.)	0.36 (.47)
150	0.5 mm. Cu. (+1.0 Al.)	0.6 (.8)
175	0.75 mm. Cu.	0.9 —
200	0.9 mm. Cu. (1.0 Cu. + 1.0 Al.)	1.2 (1.3)

TABLE IV

Lab.	K.V.	Ma.	F.S.D.	Filter		E.D.	H.V.L. in Al.	R.V. ⁶
				Cu.	Al.			
1	80	2	30	—	—	7	.6	130
4	100	3	20	—	—	2	.7	460
5	100	5	30	—	—	3	.7	330
6	100	5	30	—	—	4	.9	320
7	110	5	22.5	—	—	1.25	.9	185
8	120	3	25	—	—	5	.9	320
11	130	5	30	—	—	2	1.4	250
6	100	5	30	—	1.0	7	2.0	240
7	100	5	22.5	—	1.0	3.25	1.8	205
11	130	5	30	—	1.0	4	2.5	290
11	130	5	30	—	2.0	5.5	3.3	300
1	100	5	30	—	3.0	10	3.6	265
5	120	5	30	—	3.0	5	3.8	145
7	100	5	22.5	—	3.0	10	4.0	325
11	130	5	30	—	3.0	7.5	4.5	320
2	127	4.5	30	—	4.0	10	4.0	225
9	100	25	50	—	4.0	11	3.6	180
11	130	5	30	—	4.0	9	5.0	360
3	140	20	50	—	5.0	12	5.9	660
5	136	5	30	—	5.0	9	5.0	180
9	140	25	50	—	6.0	14	6.0	600
2	127	4.5	30	—	7.0	20	5.0	275
1	110	5	30	.25	1.0	35	11.0	185
10	130	5	30	.25	1.0	26	10.0	450
11	130	5	30	.25	1.0	30	10.0	450

⁶The Roentgenvalue (see text) is expressed in roentgen units identical with the c-unit of Duane.

for estimating the variations of the erythema due to the different conceptions of the radiologists, but also should permit certain deductions regarding our first stated question. At the same time the figures give us an idea of the range of safety, because it may be assumed that no laboratory reported here uses a higher dose than the maximum safe dose. In Tables IV and V the results of our measurements are represented. The number of roentgen units corresponds to the primary energy, the ionization chamber being placed free in air. Following Hol-

thusen, this value may be called "roentgen value." It is quite evident that considerable fluctuations in the erythema dose of the various radiologists exist, fluctuations which are surely beyond the difference in the average susceptibility of the patients. There can be no doubt, for instance, that the application of 130 roentgen units, unfiltered, produces a different shade of red in the skin than one of 460 units. However, all roentgenologists speak of it as their erythema dose. While the variations with filtered radiation are not so high, there is still enough

TABLE V

Lab.	K.V.	Ma.	F.S.D.	Filter		E.D. in Min.	eff. Cu.	H.V.L. in Cu.	R.V. ⁶
				Cu.	Al.				
1	200	5	50	.5	1.0	77	.16	.92	965 ⁷
10	180	5	50	.5	1.0	65	.164	.92	725
11	200	25	50	.5	1.0	14	.16	.92	600
15	200	25	50	.5	1.0	12.2	.15	1.0	435 ⁸
16	150	3	80	.5	—	300	.164	.7	540 ⁹
12	220	4	62.5	.75	1.0	80	.148	1.0	475
15	200	25	50	.75	1.0	15.6	.15	1.0	690
3	200	30	50	1.0	1.0	22	.13	1.3	890
4	210	4	60	1.0	1.0	180	.12	1.4	875
7	200	30	50	1.0	1.0	24	.14	1.3	790
8	200	4	60	1.0	1.0	210	.14	1.3	890
9	200	25	50	1.0	1.0	34	.13	1.3	1110 ¹⁰
11	200	25	50	1.0	1.0	22	.138	1.3	665
13	190	20	50	1.0	1.0	30	.13	1.3	790
14	200	5	60	1.0	1.0	136	.15	1.0	350 ¹¹

⁶The Roentgenvalue (see text) is expressed in roentgen units identical with the *e*-unit of Duane.

⁷Seven hundred sixty *R* produced no erythema.

⁸Threshold value for erythema.

⁹Constant potential machine.

¹⁰Given in fractional doses only.

¹¹No erythema observed.

difference to make it impossible to form an exact opinion on this basis as to the relation between penetration of roentgen rays and the number of roentgen units required for an erythema except a very general impression that more energy is usually administered in deep therapy work than in superficial therapy.

This variance in erythema doses induced us to expose small fields of 1.5×1.5 cm. on the flexor side of the forearm. The effect of back-scattering on the total dose is negligible within a wide range of penetration when using such small fields. To our surprise, we found that 600 *R* (130 K.V., unfiltered) as compared with 600 *R* (200 K.V., 0.5 Cu. plus 1.0 Al.) caused a reddening of the skin definitely within the first degree of reaction, with a slight preponderance of the field exposed to unfiltered rays (See Fig. 4). As control experiments another series of exposures at 130 K.V. (unfiltered, 1, 2, 3, 4, Al., 0.25 Cu. plus 1.0 Al.) with increasing energy (See Table IV, roentgen units of Laboratory 11) were undertaken. Although the values used should represent threshold values for the erythema, no uniform reaction was observed. As a

matter of fact, the field exposed to copper-filtered radiation which received the highest number of roentgen units displayed the most marked erythema. It seems, therefore, that Holthusen (5) is correct in stating that from 64 K.V. (6 mm. cardboard) up to 186 K.V. (1.0 mm. Cu. plus 1.0 Al.) the same primary energy as expressed by the number of roentgen units may safely be administered. We should like to restrict this statement and say that no immediate harm or injury results from this procedure but that only observations over a period of years will enlighten us regarding the possibility of late reactions following the application of what is considered to-day a rather high dose of unfiltered roentgen rays. For the present, we feel free to recommend the following doses as safe according to our experience (Table VI). We would prefer to call those doses "tolerance doses" because the term "erythema dose" implies a unit but it is certainly too flexible to represent a unit or a dose. Similar "tolerance doses" for diagnostic work have been published by one of us (Pohle, 12).

A close study of the curves offered by Meyer and Glasser expressing the fact that with decreasing wave length the number of roentgen units required for an erythema in-

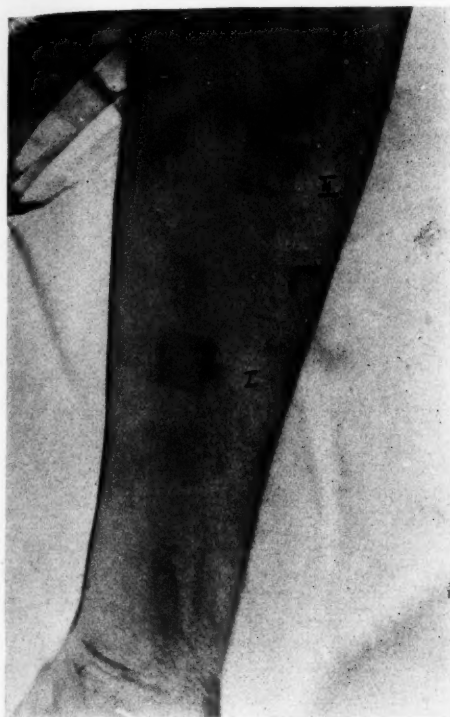


Fig. 4. Erythema following exposure to radiation of different quality. Field 1: 130 K.V., unfiltered, 600 R. Field 2: 200 K.V., 0.5 Cu. plus 1.0 Al., 600 R (primary energy).

creases if large fields are used, reveals some interesting facts. These authors state that the erythema dose should be measured on the patient, thus including the amount of energy due to back-scattering. It is evident that in such a case the curve must have a slope and can not be a straight horizontal line, even if the same number of roentgen units as measured in air is chosen as dose for all degrees of penetration. One must remember that the percentage of back-scattering increases with decreasing average wave length. Figure 5 illustrates that point much better than words. The number of roentgen units required for a skin reaction of moderate degree is plotted against the half value layer in aluminum. Curves A (including back-scattering) and B (ionization chamber in air) are taken from Meyer and

TABLE VI

K.V.	Filter	R.V. in Duane units
60-130	0	200-300
60-130	1-4 Al.	350
60-130	0.25 Cu.	400-450
150-200	0.5-1.0 Cu.	500-600

Glasser's paper (3) while A_1 and B_1 represent our own findings. Curve B_1 , expressing the roentgen value, i.e., the primary energy in air, is a straight horizontal line, assuming, with Holthusen, that the same roentgen value may safely be used through a wide range of penetration. When recording the dose on the patient in a field of 20×20 cm., we arrive at values, seen on Curve A_1 . It will be noticed that the incline is much smaller under these conditions than on Curve A, taken from Meyer and Glasser. Our measurements were carried out during treatments with the Siemens Dosimeter to which a Glocker chamber had been attached. Three days before this meeting we noticed in the latest issue of *Strahlentherapie* (1927, XXVII, 146) a paper by P. Hess, whose results regarding the above discussed problem are not very much different from our own, when comparing the roentgen values.¹² Further investigations, extending down to the very long waves of X-rays, are under way in our laboratory.

However, we have seriously asked ourselves the question if such a curve can be of real value at all, because a well defined energy unit (roentgen unit) is plotted against something almost undefinable, namely, the "erythema dose." Similar objections have been voiced by Schall, as quoted in a paper by Kuestner (13), who conducted a questionnaire among twelve German clinics,

¹²In the meantime Hess has published further investigations of this problem. The calibration in roentgen units was checked by the Department of Physics, University of Bonn. He comes to a full agreement with Holthusen's and our own results. The radiation used extended from 60 K.V. unfiltered to 185 K.V. filtered through 1.0 Cu. plus 1.0 Al. (*Strahlentherapie* 1928, XXVII, 734.)

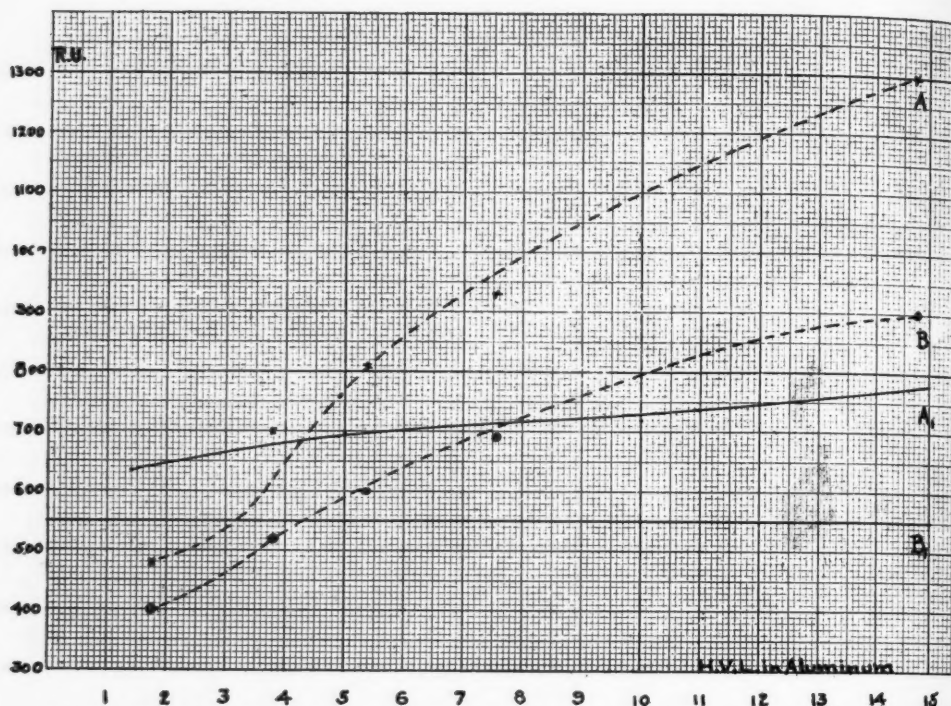


Fig. 5. The abscissa gives the half value layer in aluminum, the ordinate the number of roentgen units required for a medium skin reaction. Curves A and A₁ include the amount of back-scattering; Curves B and B₁ represent the primary energy in air. The dashed lines are taken from Meyer and Glasser's paper, the straight lines are our own curves.

using the same standard instrument for checking the output of their equipment. In conclusion, the dose of 551 German R (without back-scattering) plus or minus 15 per cent is offered as a "statistical mean value" for a safe degree of skin reaction, which is in fair agreement with our own value (see Table VI).

The roentgen unit we have used throughout this paper is identical with the electrostatic unit (e) as defined by Duane. In view of the much discussed discrepancy between the so-called American and German units, a brief account regarding our experience in this field follows:

Our Wulf Ionometer was calibrated in Germany on September 23, 1926; for filtered radiation of short wave length there were 4.7 German R per scale. A recalibration of the instrument upon its arrival in

New York, in Glasser's laboratory, on December 21, 1926, gave 7.5 American R per scale, a difference of about 60 per cent. The instrument reached Ann Arbor, Michigan, on the first of the year and we standardized our apparatus on January 3, 1927, in both German and American units, at the same time transferring the units to our Siemens Dosimeter. The latter is checked, as related in Chapter I, by an uranium standard and its readings are, therefore, reproducible. The ratio of the two instruments gave the factor 1.13. Repeated checks (see Table VII, Column 5) revealed fluctuations in this relation not over plus or minus 3 per cent. Beginning October 18, 1927, daily radium controls were carried out following the suggestion of Kuestner (14), using 50 mg. of radium, filtered through 1.0 brass plus 1.0 aluminum plus 1.0 lead, which were placed

TABLE VII

Date	Am. R.	Gr. R	Duane E	W.I. ¹³ S. D.
9-23-26	—	4.7	—	1.13 on 1-3-27
12-21-26	7.5	—	—	1.07 on 7-28-27
10-24-27	—	—	5.04	1.09 on 11-11-27
11-14-27	5.4	—	—	1.08 on 11-15-27

The figures are roentgen units per scale for filtered radiation as used in deep therapy.

($\lambda_{\text{eff}} = .17 - .14\text{\AA}.$)

¹³Ratio of Wulf Ionometer: Siemens Dosimeter.

in axial position 3 cm. from the tip of the chamber. We were, therefore, somewhat surprised to find 5.04 *e* per scale for deep therapy radiation when calibrating our Wulf Ionometer in Professor Duane's laboratory in Boston, on October 24, 1927. This corresponded to a difference of 50 per cent from the so-called American roentgen unit and was independent of the wave length for 150 K.V., no filter, to 1.5 Cu., but brings the value within 8 per cent of the German roentgen unit as originally laid down in the Wulf Ionometer. The instrument had been checked, before and after the trip, with radium, and also against the Siemens Dosimeter, showing very satisfactory constancy. A recheck against Glasser's instrument in Cleveland,¹⁴ on November 14, 1927, indicated 5.4 *R* per scale. From comparisons before and after the latter trip, with the Siemens Dosimeter, we were satisfied that only a negligible change of 1 per cent had occurred in the sensitivity of our Wulf Ionometer. We are at a loss to explain this variation in the face of the fact that our instrument has proved to be very constant if kept under the same atmospheric conditions. It is hoped, however, that a re-checking of the roentgen unit as defined in this country and abroad under all possible precautions

will lead to a better agreement in the near future. One deduction can be offered as a result of these measurements. Unless an ionization instrument is checked by a constant known source of radiation, as, for instance, Gamma rays of radium, it is inadvisable to attempt the transfer of the quantitative factor in the calibration of an X-ray machine.

III. THE REPRODUCTION OF THE BIOLOGICAL EFFECT OF ROENTGEN RAYS

One of the most important problems in the field of roentgen ray dosimetry is the question as to whether the biological effect can be reproduced if the same quality and quantity of X-ray energy is administered. From the discussion in the previous chapter we have seen that the erythema dose is not very suitable for such an investigation. It could almost be believed, then, that there is no reason for measuring the dose in roentgen therapy if certain considerations did not convince us to the contrary. One of the supreme rules in medicine is that only a known quality and quantity of a medication, be it a drug or a physical agent, should be administered to a human being. Furthermore, we know how easily an excessive amount of radiation may be given and may lead to a serious injury. It is for the protection of our patients, then, that we should be well aware of what we are doing when carrying out radiation treatments.

There is a possibility, however, of proving that the same biological effect can be produced by the identical quality and quantity of X-ray radiation if a suitable test object is chosen. We have taken the left and right forearm of the same patient and exposed four fields with radiations of different penetration, produced by two different machines and tubes. The effective wave length and the number of roentgen units per minute were measured on one machine of

¹⁴In transit the amber insulation must have suffered, because the natural leakage of the Wulf Ionometer was higher than under normal conditions.

the mechanical rectifier type and the patient then exposed to a dose which we were sure would produce an erythema. With the ionization instrument, the selected dose was transferred to a machine of the kenetron type and additional areas on the arm of the same patient irradiated. This allowed a direct comparison of the two series of treated areas. The reactions appeared at the same time and were of equal intensity. Although these tests have been carried out so far only with superficial technic (100-130 K.V., no filter, and through 1.0 Al.), we believe this to be acceptable proof of the true reproduction of the biological effect of roentgen rays. Our experiments will be continued, particularly with short wave length.

Another reason why we should measure our dose as exactly as possible is that we may establish comparable statistics. This does not mean, however, that, if a certain clinic reports good results in some type of tumor case with a certain dose, these results can be reproduced anywhere else by administering the identical dose. Into this problem enters the variation of the individual patient, of his constitution, and of the type of the disease. Here is where the question becomes a decidedly clinical one, where the kind and amount of treatment has to be controlled by medical skill and experience. It is a phase of radiotherapy which has been slightly neglected during the last few years. The value of those statistics lies in the fact that they may serve as guides to others who are beginning their work in this particular field. In the same sense we regard the publication of tolerance doses (see Table VI) as suggestions only, leaving it to each radiologist to decide as to his own maximum doses. Their value for medico-legal purposes is, however, obvious; figured on the basis of extensive material, they represent the amount of roentgen ray energy which may safely be given according to our present state of knowledge.

SUMMARY

1. The absorption curve in copper (above 140 K.V.) or in aluminum (below 140 K.V.), measured by the ionization method, represents perhaps the best quality factor in roentgen therapy to-day. We can read from such a curve, the absorption coefficient, the average wave length, the effective wave length, and the half value layer. The photographic method (Meyer) may be used for orientation; its results do not always agree with the figures obtained by ionization measurements, particularly in the range of longer wave length.

2. The erythema dose is unsuitable as a unit in dosimetry; the roentgen energy administered to the patient should be expressed in roentgen units. "Tolerance doses" in roentgen units are offered which represent mean values for a safe exposure. Duane's *c*-unit which should be identical with the *roentgen unit* has been adopted in our work. The statistical mean value for an erythema in deep therapy as computed by Kuestner in Germany is 551 *R* plus or minus 15 per cent (without back-scattering). It agrees well with our tolerance dose of 600 *R* (ionization chamber in air) for filtered roentgen rays of short wave length.

3. The biological effect of roentgen rays is reproducible if tests are conducted without introducing individual variations. For clinical purposes, each radiologist should choose his own dose; in other words, write his own prescription for radiation. Tolerance doses in roentgen units deduced from observations on extensive material are of value as guides and also from a medico-legal standpoint.

4. In closing, we wish to express our appreciation to all radiologists whose co-operation has made this study possible. We feel particularly indebted to the Dean of the Medical School, University of Michigan, Dr. Hugh Cabot, who generously provided the funds to carry out the many trips for

calibrating the X-ray apparatus reported in this paper.

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DISCUSSION

DR. W. E. CHAMBERLAIN (San Francisco): Dr. Erskine's symposium is supposed to be on practical dosimetry. Dr. Newell and I for a long time have rather distrusted this idea that the erythema dose was something we could all tie to. It seemed to us that an erythema dose differed by as much as 1,500 per cent from one laboratory to another, and that no one could say that a certain definite degree of skin reaction should be the exact erythema dose. We fondly hoped that we might find some biological effect which was capable of being spoken of more exactly, and we chose percentage of epilation as that biological factor for study. When we started this work at Dr. Erskine's behest, we fondly hoped that we would find out that a certain number of *R*-units would produce a certain percentage of epilation in certain parts of the body. Whether we succeeded or not will appear in a few moments. (See p. 280.)

PROFESSOR H. BEHNKEN (Charlottenburg, Germany): In regard to the dosimetric problem of to-day the following question is a typical one: "How many X-ray units are needed for the production of an erythema?" Here we are looking for a relation between two principal conceptions, a physical one, the unit of the dose, and a biological one, the erythema. If it is true that these two conceptions are securely in our hands, we should be able to answer our question without difficulty. However, our question has not been completely answered until the present time. What is the reason? Let us look at our principal conceptions in detail. As a physicist I am most interested in the first of them, the unit of the dose. For my part I am convinced that there is nothing left to be desired about the definition of the *R*-unit, either from a theoretical point of view or in regard to the technique of the measurement. Until a few weeks ago I was not so sure in this belief. You all know the recent publications of Glasser, who compared a series of dosimeters calibrated in Germany and sent to this country. These dosimeters showed disagreements between one another and also the average value of the unit as measured by these instruments differed from Glasser's unit by about 40 per cent, although theoretically there should have been no difference. From this result, confidence in the *R*-unit has tended to become uncertain. It has seemed to me that the safe possession of the unit would be an important fundamental of the solution of the dosage problem, and that is the reason why I came to this country with some dosimeters constructed particularly for safe transportation of the calibration instead of for practical measurement. Before my trip, I had them calibrated as exactly as possible with a compressed air chamber in Germany and during the last three weeks Glasser and I have compared them with Glasser's standard ionization chamber. If

there had been a difference, it would have meant that there was indeed a defect in the definition of the unit. The measurements recently completed, however, have shown that there is no difference between our units which would make them unreliable. From that we may conclude that the definition of the unit is good as it stands and need not be changed. However, what must be changed is the kind of instruments which gave the bad results at the first comparison made by Glasser. These bad results show that it is necessary to equip all practical dosimeters with some control arrangement, by which we can determine, at any time or place, whether or not the instruments have kept their calibration. If they have not, we must be able to determine the required correction. Some radio-active substances give us the means for such a control. For this purpose, I prefer the uranium oxide, because it is cheap and my almost daily use of it for more than four years has shown that there is no danger of any mistake. I also believe that with the γ -rays of radium, correctly used, good dosimeter control is possible. Therefore, it must be demanded from a concern constructing dosimeters that the instruments shall always be provided with control facilities. Examples of such well controlled instruments are, up to the present time, the Siemens Dosimeter and the Eichstand instrument of Küstner.

This was only one important point about the dosimeter problem. In order to spare your time I may only mention another one without any detailed discussion. That is, the practical dosimeters in the future should make it possible to measure the dose or the dose per second directly at the patient, at least at the surface of the body. I think that it will be possible to construct such instruments similar to those mentioned by Glasser. The physician should not hesitate to learn thoroughly the technic of measuring and should always make use of it. Finally, let me say that I have the impression that

part of the difference between the high number of *R*-units in America, especially those I saw at Cleveland, and the lower ones adopted in Germany may be explained by the higher degree of the reaction in the American erythemas. I am a physicist and not a physician, and it may be that I am not a competent judge. I am as doubtful as Dr. Pohle whether the erythema is a sufficiently defined reaction for an exact comparison of doses.

DR. U. V. PORTMANN (Cleveland, Ohio): I am sure that we all appreciate the visits of Professor Holthusen and Professor Behnken, who have given us so much information. The former, who has covered the subject of the roentgen dose exceedingly well from the standpoint of the X-ray therapist, has shown that we can no longer depend upon mechanical factors for the accurate determination of dosage nor can this method be used to duplicate the dosage of others. Individuals often state that in cases of epithelioma of the lip, for example, they use certain mechanical factors giving five or ten erythema doses and that this dose will destroy the malignancy; yet they did not actually give as much radiation as they thought they were giving because they were using small fields of various sizes with different amounts of back-scattering and the actual dose was comparatively small.

I agree with Professor Holthusen that the method of choice for the measurement of radiation dosage is the ionization method and that the quality of radiation is satisfactorily determined by the half value layer in copper or aluminum. The large air chamber which he demonstrated is a standard or checking instrument and is impracticable in the treatment room. Other types of dosimeters must be calibrated by this method. For treatment, I think that we should employ an instrument which can be placed directly upon the patient's skin, because, by this procedure, the total dose is measured.

which includes the direct focal radiation as well as the back-scattering from large and small fields and in any volume of tissue. This point is apparently responsible for some of the disagreements and dissension at this time. I believe that it is impossible to extrapolate for the many factors which influence the radiation dose unless an ionization chamber or some other instrument is applied directly to the skin. This is an important factor in causing the difference between our unit of dosage and the German *R*-unit—we measure the dose on the skin. I have been using, for example, 1,300 *R*-units with hard rays as a maximum erythema dose, whereas in Germany they would use only 800 *R*-units for the same dose.

The interesting experiments of Dr. Pohle represent only the determination of a minimum dose for small fields of radiation. According to our experience the same amount of dosage as measured in large areas on the skin can not be administered with unfiltered or the softer rays as can be given with the hard rays. The method originally used by Glasser and Meyer in the determination of their dosage curve included the back-scattering from large areas.

Dr. Chamberlain in his original and efficient epilation experiments also used small fields and did not take into consideration the back-scattering nor the volume of tissue. It is well known that ultra-soft X-rays, with their superficial absorption, will not cause epilation, and when intermediate voltage is used it requires an erythema and a half, but with hard rays I have frequently caused epilation of the scalp with less than 60 per cent of an erythema dose in fields 10×15 cm. It is, therefore, certain that there is some variation in the reactions to different wave lengths and especially in the epilating effects.

It is my opinion that the best method at present for practical treatment purposes is to use a properly calibrated dosimeter with an ionization chamber which has the same

absorption value as atmospheric air and which can be directly applied to the skin of the patient within the field of radiation.

DR. A. U. DESJARDINS (Rochester, Minn.): Three important factors enter into the question of practical dosage: the quality of the rays, the quantity of the rays, and another factor, which I might almost call *X*—the patient, whose condition is not often considered as much as it should be. If Grothus' law, according to which the biologic effect of the rays depends on the radiation absorbed by the cells, is as fundamental as it appears to be, the quality of radiation is as important as the quantity. The best method available to-day for measuring the quality of radiation is spectrometry. So far as the quantity of the rays is concerned, there has been a great deal of controversy for several years about the best method of measuring this and especially about the most desirable unit of measurement. Fortunately, the divergences of opinion have diminished gradually and at the present time the outlook for a satisfactory solution of this question is especially bright.

As you know, there are two schools of radiotherapy: the disciples of the one school feel that quantity of radiation is the all-important factor and attempt to treat all conditions with the same quality of rays, the quantity alone being modified according to the condition being treated; the other school feels that quality is as important as quantity, because only rays absorbed by the cells can be expected to produce changes in the cells. Unabsorbed rays cannot be expected to produce any cellular reaction.

So far as the patient is concerned, the size of the field makes a tremendous difference. A dose three to five times as great can be given to a small field as to a large one, without any break-down of tissue. The quality of radiation also affects the reaction of the skin and superficial tissues. A strong dose of soft rays applied to a field of some size

will often lead to ulceration, whereas a corresponding dose of much harder rays often does not produce ulceration, or, if so, only after a much longer latent period. The reaction of the skin and other tissues to strong doses of rays of short wave length often consists in a leathery atrophy of the skin with dense induration and adhesion of the underlying structures. There can hardly be any argument about the importance of arranging the quality of the rays so as to obtain maximum absorption at the level of the lesion under treatment. Cases showing the importance of the quality of radiation are seen almost every day. The pathologic character of the tumor is more important than its depth below the surface. Nevertheless, the level of the tumor should not be disregarded and the quality of radiation should be adjusted accordingly. From this it is obvious that many factors enter into the treatment of tumors, and the only one who can judge of the relative importance of these different factors in a given case is the physician, because he alone can evaluate the effects on the patient.

DR. L. S. TAYLOR (Washington, D. C.): I have two points I want to bring up, neither of which is exactly in the way of amplification of anything that has been said. There is one rather surprising thing, and that is in the final agreement of all of the various defined units for X-ray dosage. Up until this year, when a dose was represented as so many units of one kind or another, nobody knew within 40 or 50 per cent what the writer was talking about. The four principal units which, while they do not disagree in any fundamental respect themselves, in their practical measurements in the past have been open to a great deal of disagreement, but now the units of Duane, Glasser, Behnken, and Solomon, under a new definition, have been brought to agreement within about 7 per cent, which shows a great advance, one of the greatest steps to this end

being made in the last few weeks, when Dr. Behnken and Dr. Glasser brought their two units into close agreement.

The other comment I wanted to make I fear is largely lost, because the men I wanted to reach most of all are the ones who have gone; namely, I wanted to make some mention of the program that the Bureau of Standards in Washington is undertaking. No doubt most of you here know that such a program has been started, and that we hope in a short time to have located at the Bureau of Standards a center of X-ray dosage standardization. While I do not mean to disagree particularly with Professor Behnken, I might say that we are still open to conviction as to what our program should be. The actual definition and name of the unit is a matter which the Bureau of Standards has not yet acted upon, nor has it decided upon the method of making standard measurements with any agreed unit. We hope that very shortly this question will be settled, and, when it is, proper publication will be made so that use may be made of this fact by physicians. No small part of the general program besides the immediate study of standardization, includes the very important program of organized inspection of therapy and diagnostic hospital equipment in general. It is planned that, as soon as this standardization program is completed, the Bureau will organize a staff of trained technicians who can go from place to place and measure with accuracy the amount of scattered radiation in any X-ray establishment, and, having made those measurements, they can recommend improvements—not only improvements in a general way, but improvements in the design and outlay of therapy equipment. We hope that, when this stage is reached, the physicians will co-operate as we are trying to co-operate, namely, take the suggestions not as criticisms but as suggestions to help the whole cause. I might just say, by way of conclusion, that our whole

spirit is one of co-operation, and we hope that the program of the Bureau of Standards may receive the co-operation and support of organized radiology, and that our work may be acceptable and desirable to the medical profession.

DR. P. M. HICKEY (Ann Arbor, Mich.): I just want to get up and say a word in commendation of the work which Dr. Pohle has been doing. I think the important finding in his work is that the so-called erythema dose varies tremendously, as shown by his calibration of various machines in connection with the clinical use of those machines. The term "erythema dose" should probably no longer be employed and we should substitute for it "toleration dose."

I think a most important thing has come out this afternoon, *i.e.*, that there is a very close relationship, amounting to almost an equality, between the so-called "roentgen dose" and the dose which was laid down by Professor Duane in 1914. Now that this agreement has been brought out, the problem is very much simpler and the International Congress will have, on the American side, a very much easier problem than if the roentgen dose had not been established. I have also to add that, through the efforts of Dr. Pohle with the Department of Physics of the University of Michigan, the University is now prepared to calibrate machines for the workers of the State of Michigan and its immediate vicinity, so that there can be a very definite equality of dosage established. I think that that is pioneer work on the part of our University.

DR. A. MUTSCHELLER (New York): To be radical is often risky, but if, later on, one's contentions are ultimately supported and justified, that is indeed very gratifying. Dr. Pohle has stated in his paper that he found discrepancies between the half value layers when measured by ionization or by the photographic method. He further con-

cluded that the half value layer method is really not fully satisfactory as a description of radiation quality. Furthermore, Dr. Chamberlain in his paper pointed out discrepancies, perhaps even larger ones than those mentioned by Dr. Pohle. Now, for such or similar reasons, before this Society in Chicago, I believe in 1923 or 1924, I presented a paper wherein I pointed out some of the pitfalls possible in the estimation of the quality and the quantity of X-ray radiation doses and suggested, for a definition of the quality of X-ray radiation, a method of measuring the quality of a radiation and a term of expressing it which I call average wave length. This wave length should not be mistaken for effective wave length or the half value layer, which give different results under various conditions and with different radiations. The average wave length has but one value for every radiation, irrespective of the filter thickness or other variations. As formerly pointed out, it is determined from an absorption curve using any convenient metal as an absorber and then the average wave length is either calculated or read from a curve. The definition of the average wave length is that it is the wave length of a homogeneous radiation which has the same absorption coefficient as the non-homogeneous radiation which is being tested. This average wave length or definition of average wave length is, therefore, an interpretation of the absorption curve referred to by Dr. Pohle, and I feel, therefore, that, in view of the errors and discrepancies of the other methods of quality determination, there is a justification for continuing to sum up the experimental data which prove that the average wave length is indeed a much better definition of the radiation quality than the now so frequently used half value layer. A full discussion of this subject and a summary of this material, I shall take the liberty to present to this Society at a later opportunity.

DR. I. SETH HIRSCH (New York): I think that Professor Behnken has stated the problem very clearly. It is necessary, first, to determine on a physical unit of radiation. It matters little whether the stem radiations, or stem radiations plus the radiations from the target, or only the target radiations are measured. The important thing is a physical unit of radiation. And it would appear from the papers we have listened to this afternoon that we are in a fair way to get this much-desired standardization. The difficult problem is to connect this physical unit of radiation with a unit of biological reaction. Neither erythema nor epilation can be used as a unit of reaction or of biological effect. Dr. Chamberlain has shown this very well, and his results are in harmony with the experience of every one who does radiation therapy. The problem is difficult because of the extreme variability in the reaction of the particular tissue utilized in the biological test. This is due to the inherent varying resistance of tissues to the trauma of the radiation; and, secondly, to the variability in the reaction of the same tissue, depending on the rate at which the radiation is applied to it. And this includes not only the time factor as such, but also the absorption rate as it is influenced by the wave length.

Thus the formula for dosage, if we are to have standardization, would have to express the hardness of the radiation in terms of effective or average wave length, number of portals, expressed in areas of square centimeters, and the rate at which the radiation is applied to the tissues—so many *R*-units in so much actual time of exposure. All we would then have to contend with would be the unstandardizable and unmeasurable factor, the reaction, local and general, of the patient. This requires clinical judgment and clinical and pathological experience. We owe a debt of gratitude to Professor Behnken, Professor Holthusen, and Professor Glasser and the rest who are devoting

their time to determining a simple, easy, measurable, definite unit of radiation.

PROFESSOR HERMANN HOLTHUSEN (Hamburg, Germany): In closing this discussion, which has been, as far as I can see, very valuable to all of us, certainly to me, I only want to stress some things which have been discussed. I cannot take up all of the points which have been discussed to-day, because it would take me nearly the whole evening. I want to say that our intention was to make the dosage measurement simple and reliable, and for that reason I wanted to present to you a method which fulfilled both of these requirements. If Dr. Glasser tells us that he has a small ionization chamber wherewith he is able to measure the skin dose, it is certainly very great progress and I think we can congratulate him. At the present time this exists, so far as I can see, only in the laboratory of Dr. Glasser, and so I was not able to recommend it at the present time, but I am quite sure that future progress lies in that direction.

As regards the measurement of quality, it was also my intention to give you a simple method. I think the most simple method is just to take a second reading besides the reading of the intensity of the dosage, and determine the thickness of filter which you have to put in in order to reduce the value of the intensity one-half. I wanted to show you a table giving the quality with various voltages and filter thicknesses, and other data. It was not my intention to give you a physical method of measuring the quality. Now, the most interesting point and the point of most practical value is the question as to whether one must vary the number of units as measured with this instrument according to the quality of the rays. All I can say—and I must insist upon it—is that when using this instrument, it is not necessary to change the number of *R*-units per erythema when changing from a hard radia-

tion to a soft radiation, and I think the experiments which Dr. Chamberlain has shown us are quite in agreement with that. The experiments of Dr. Glasser do not agree with it at the present moment, but I hope that on my way back I shall be able to stop in the laboratory of Dr. Glasser, and, in the same way as Dr. Behnken and Dr. Glasser have come to an agreement, I hope we shall also come to an agreement so that this question can be settled. As regards the number of *R*-units necessary to produce the same kind of a skin unit dose, it is also my impression that the number of *R*-units given in America in some institutions is larger than in Germany, as judged by the intensity of the skin reaction, so that I think the

agreement between Dr. Behnken and Dr. Glasser is quite understandable.

A MEMBER: I would like to ask Professor Holthusen if he can give the variation of his ionization time due to air density and the variation due to the variation of the machine itself? We have found that the ionization time is considerably longer at high altitudes than it is at sea level.

PROFESSOR HOLTHUSEN: This does not interfere with the measurement, because we use the radium standard, and when the air density becomes lower the effect of the radium standards also becomes less.

REPORT OF THE COMMITTEE ON STANDARDIZATION OF
X-RAY MEASUREMENTS OF THE RADIOLOGICAL
SOCIETY OF NORTH AMERICA

1. The unit of effective X-ray intensity, "*one R*," is that intensity of radiation which produces a saturated ionization current of one electrostatic unit per cubic centimeter of a non-restricted volume of air at a temperature of 0° Centigrade and a pressure of 760 mm. of Hg.

2. The method recommended by the Committee for the measurement of X-radiation in terms of the above unit in a non-restricted volume of air is the employment of an air ionization chamber—

- (a) with open windows at the sides of incidence and emergence;
- (b) with guard electrodes sufficiently large to insure the desired electric field;
- (c) with suitable spacing of electrodes to include sensibly all of the ionizing effects of the photo-electrons;
- (d) an arrangement of diaphragms to properly collimate the beam and prevent undesired secondary radiation effects.

Such an ionization chamber constitutes an "absolute standard."

3. The measurement of the X-radiation at the place of practical application may be made by a dosimeter which is calibrated in *R*-units by means of an "absolute standard." Such a dosimeter constitutes an "absolute standard."

Preferably a practical dosimeter should have an ionization chamber in which the measured ionization current is proportional to that produced in an "absolute standard" with the various qualities of radiation employed. The constancy of such a dosimeter may be satisfactorily controlled by means of a suitable radio-active substance properly employed.

4. Voltage and filtration alone do not

properly define radiation quality. Spectrometric analysis of the X-radiation gives the most complete determination of its quality. For practical purposes the quality may be expressed by the half value layer in a suitable material (copper or aluminum is recommended) or by the effective wave length.

The half value layer for the X-radiation employed is that thickness of the given material which will reduce the reading of the "absolute standard" or "calibrated standard" to one-half of its value.

The effective wave length of the X-radiation employed is the wave length of monochromatic radiation for which the readings of the "absolute standard," or "calibrated standard," would be reduced in the same ratio as that actually observed when a certain thickness of a given material (copper or aluminum) is interposed.

5. The Committee recommends that dosage be expressed in terms of *R*-units and time of application, and that the quality of the radiation be stated in terms of effective wave length or half value layer.

Respectfully submitted,

Committee on Standardization of
X-ray Measurements

EDWIN C. ERNST, M.D.,
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LAURISTON TAYLOR.

ROENTGENOGRAPHIC EXAMINATION OF THE BASE OF THE CRANIUM IN THE PRESENCE OF BASAL TUMORS

TECHNIC AND METHOD OF DIAGNOSIS¹

By ERNST G. MAYER, M.D., VIENNA

TRANSLATION FROM THE GERMAN BY HENRY RIGGS WOLCOTT

ROENTGENOGRAPHIC examination of the base of the cranium in the presence of a basal tumor more frequently yields practical results than would be anticipated if a judgment were to be based on the small number of articles on the subject appearing in the literature. Recognition of the changes that take place in such cases requires, to be sure, a thorough study and a comprehensive knowledge, particularly of the numerous variations that appear at the base of the cranium, which might easily give rise to false conclusions. The fact that a large number of skeletal parts of complicated structure lie one above the other on the plate, and, furthermore, are exceedingly variable in form, as is the case at the base of the skull, makes it of course much more difficult to get one's bearings. But the recognition of the various details of the roentgenogram and the interpretation of the whole will be possible if one forms the habit of working with a skull in hand, comparing constantly the roentgenogram and the skull, and learns to figure out on the skull the exact angle from which the roentgenogram was taken. Correct and appropriate technic in the taking of roentgenograms is a precondition of success and makes it possible to limit the roentgenograms to the actual number required, which is desirable not only for economic reasons but also in the interest of the patient, since every superfluous roentgenogram constitutes just so much needless annoyance. We must, therefore, have a clear idea from the start where we should look for changes, that is to say, where we most frequently find them,

and how we can best demonstrate them. Such considerations will determine in each case the course of the examination.

It has been our experience that, in the presence of basal tumors, our pathologic observations are made most frequently in the sella turcica, and secondarily in the pyramids. The third most frequent place of involvement is in the small wings of the sphenoidal bone, together with the optic canal, and fourthly, the great wings of the sphenoidal bone, together with the foramen spinosum, the foramen ovale, and the foramen rotundum.

THE TECHNIC OF THE EXAMINATION

In all cases in which the presence of a basal tumor is suspected, we must prepare, above all, two roentgenograms for the purpose of orientation, one in a frontal and one in a sagittal direction. While this statement may seem superfluous, experience has shown that it is necessary to emphasize this point. There are, to be sure, cases in which roentgenograms of a special part lead to an unequivocal result. However, one often finds in such special roentgenograms changes that he should not attempt to interpret other than in the light of observations made on the cranium as a whole, for the reason that such changes may constitute a local erosion as well as a variation. In preparing the frontal roentgenogram it has generally been our custom to demonstrate the sella turcica from a lateral position, in which pathologic changes in it are easily recognized. In some cases, to be sure, it has been found more desirable to demonstrate the sella turcica from an oblique angle, so that the clinoid processes may be seen

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Fig. 1. Roentgenogram of the temporal bone, after the Stenvers method. Normal.



Fig. 2. Roentgenogram of the optic canal, after the method of Rhese-Goalwin. Normal.

separately instead of the one being obscured by the other. We will take up this point again farther on.

In the case of the sagittal roentgenogram less emphasis is placed on an exact adjustment of the source of the rays, although here, as well, a certain direction has been found by experience to be best. The principal rays should take the direction of the "German horizontal" in the line of section of the sagittal plane. By the "German horizontal" we mean an imaginary line or plane passing through the lower orbital margins and the upper walls of the external auditory canal. If the roentgenogram is taken from this direction, we see distinctly the pyramids, the small wings of the sphenoidal bone, the great wings of the sphenoidal bone insofar as they form the lateral orbital wall, and often also the foramina rotunda. If the latter should occupy an oblique position with reference to the German horizontal, and therefore should not be visible from the angle chosen, or should be completely obscured by the pyramids, another roentgenogram will have to be made if they must be demonstrated, care being taken that the principal rays do not lie in the

direction of the German horizontal but form with it a dorsocranial open angle of about 20 degrees. In the two general roentgenograms, if properly made, we can recognize the most essential details, and all that is needed then is to demonstrate separately by special roentgenograms such portions of the cranium as, from the appearance of the general roentgenograms, appear particularly suspicious, or, by reason of clinical observations, deserve greater attention.

Of the numerous special roentgenograms cited, three are particularly important for our purposes, and, as a rule, we find these three sufficient. These are: 1. The axial view of the middle fossæ (after the method of Schüller), in which the central rays take the direction of the intersection of the sagittal plane with the plane passing through the two external auditory meati perpendicular to the German horizontal. With an overhanging brow, the roentgenogram should be taken in a submentobregmatic direction, if possible, in order to give a better survey of the base of the cranium (Fig. 12). If the patient cannot assume that position, the exposure may be made in the reverse direction, in which case, to be sure,



Fig. 3. Erosion of the sella turcica, caused by hydrocephalus of the third ventricle, in tumor of the posterior fossa.



Fig. 4. Roentgenogram of the temporal bone, after the Stenvers method. Uniform dilatation of the internal auditory canal, in tumor of the posterior fossa.

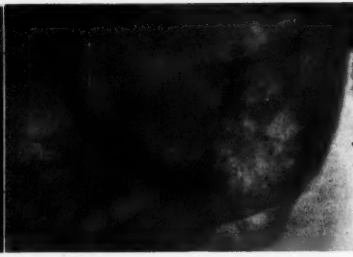


Fig. 5. Roentgenogram of the temporal bone, after the Stenvers method. Acumination of the apex of the pyramid due to increase of the endocranial pressure.

the inferior maxilla often obscures a considerable portion of the middle fossæ (Fig. 13). This view shows us the base of the great wings of the sphenoidal bone with the foramina spinosa and the foramina ovals, the body of the sphenoidal bone together with the sphenoidal sinuses, the posterior portion of the ethmoidal bone, the posterior contour of the maxillary sinuses, and the roots of the pterygoid processes; also both pyramids. On account of the high permeability of the clivus to the rays, it seldom shows up distinctly, but that is true from whatever direction the roentgenogram is taken. The base of the great wings of the sphenoidal bone is the principal thing in connection with this roentgenogram. It is ill adapted, to speak from my own experience (but in opposition to Bertolotti's observations, who has likewise occupied himself to a great extent with the roentgenology of the base of the cranium) for the demonstration of changes in the pyramids. In any event, the method described under "2" (which follows) is much better for that purpose. 2. The taking of a roentgenogram of the temporal bone after the Stenvers method (Fig. 1). In this method the main body of the rays is emitted perpendicularly to the longitudinal axis of the pyramid, so that we have in the plate a frontal

view, as it were, of the petrous portion of the temporal bone. At the same time, we get a survey of the whole pyramid, and especially of the upper contour and the apex, and can discern well also the superior and the lateral semicircular canal, the vestibule, the cochlea and the internal meatus. 3. The taking of an oblique view of the orbit after the Rhese method, applying the modification of Goalwin, in which the main body of the rays takes the direction of the axis of the optic canal (Fig. 2). It serves to demonstrate the optic canal and its immediate vicinity. These roentgenograms are generally sufficient for the examination of the base of the cranium when the presence of a tumor is suspected. Only in rare cases will these need to be supplemented by other typical or atypical roentgenograms; for example, roentgenograms of the temporal bone after the methods of Schüller and Mayer, respectively.

SPECIAL DIAGNOSIS

A.—Signs of Increased Endocranial Pressure

It is generally accepted that increased endocranial pressure may be recognized by the convexity of the lighter areas that are char-

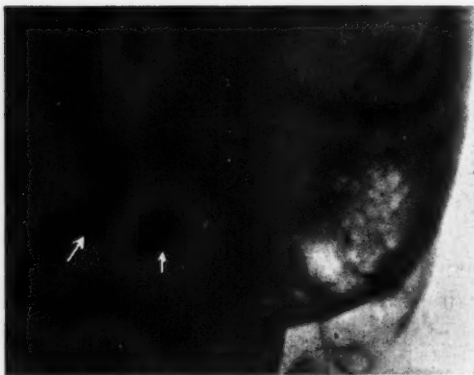


Fig. 6. Roentgenogram of the temporal bone, after the Stenvers method. Dilatation of the carotid canal, associated with endocranial increase of pressure.

acteristic for the increase and deepening of the digital impressions. I mention this chiefly for the reason that LeWald recently maintained that these areas of lesser density are not conclusive evidence of the existence of increased pressure, since he found them in a number of cases in which there were no clinical indications of its existence. He overlooks, however, the fact, well known to the neurologist, that increase of endocranial pressure does not necessarily present any clinical symptoms, and occasionally may be revealed only by an increased disposition to certain pathologic manifestations; for example, headache.

More important is the attitude toward a second question. It sometimes occurs that the roentgenograms furnish what appears to be reliable evidence of increase of pressure and yet lumbar puncture or puncture of the cisterna reveals normal conditions. How are we to explain the discrepancy in the two observations? There are two possibilities to be considered. It is well known that increase of pressure works many changes, in the course of a few weeks, in the inner surface of the calvarium. Though the increase of pressure was only temporary, the changes persist for a long time. This will explain

why we may diagnose an increase and a deepening of the digital impressions at a time when the pressure has become normal again. Of greater practical importance,

Sketch I. Eroded condition of the tuberculum sellæ and of the sulcus chiasmatis. (The dotted line shows the normal contour.)



however, is a fact which does not appear to be generally known to clinicians and which therefore deserves especial emphasis; namely, that the increase of pressure is not necessarily universal; it may affect only one hemisphere, or possibly only one cranial fossa. In such cases it is only natural that lumbar puncture or puncture of the cisterna gives a negative result in spite of a definitely known, though only partial, increase of pressure. Although the changes on the convex surface seldom permit a definite conclusion as to the site of the tumor, the superficial erosions due to pressure, noted at the base of the cranium, often supply indications as to its location. This does not apply to the same extent to the sella turcica. Here, increase of internal pressure may cause an extensive erosion that will simulate a sellar tumor (Fig. 3), which furnishes evidence that the warning never to make a diagnosis from special roentgenograms alone, but always to support apparent findings by general roentgenograms that afford a survey of the whole field, is fully justified. The only conclusion that we can draw from the pressure erosion of the sella is, that the tumor has produced a hydrocephalus of the third ventricle. Sometimes, chronic endocranial increase of pressure, owing to the fact that the tuberculum sellæ and the sulcus chiasmatis are pressed downward, produces a forward bending of the sella turcica similar to the bulging of the

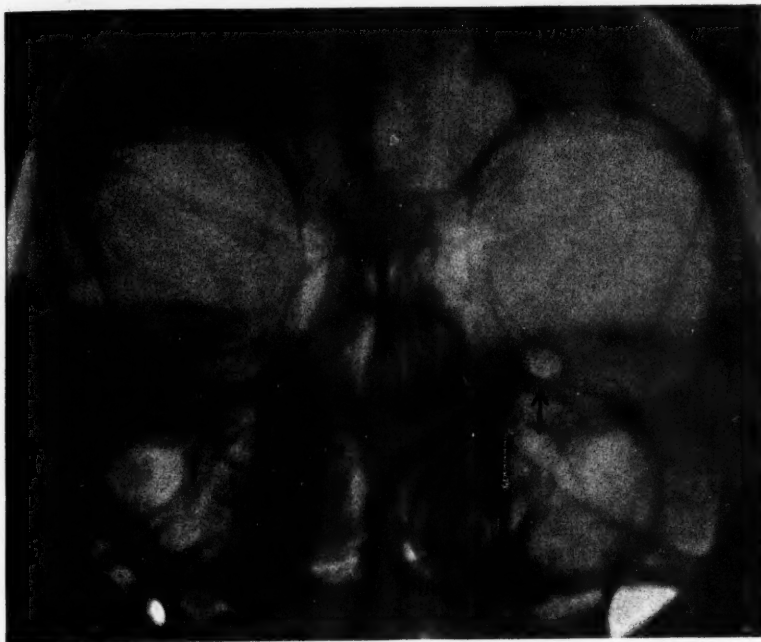


Fig. 7. Postero-anterior roentgenogram of the base of the cranium. Right-sided dilatation of the foramen rotundum in tumor of the middle fossa.

anterior lobe of the pituitary body caused by small tumors. The posterior contour of the medial roots (Schüller) of the anterior clinoid processes passes then directly into that of the floor of the sella, as shown in Sketch I.

As the changes in other parts of the base of the cranium are of great importance in making the topical diagnosis, it will be necessary to discuss separately the several cranial fossæ. Increase of pressure in the posterior fossa frequently causes uniform dilatation of the internal auditory canal (Fig. 4), and sometimes atrophy or attenuation of the dorsum sellæ. An attenuation of the squama occipitalis (particularly in the lower quadrants), which likewise may be a resulting manifestation, can seldom be distinctly observed in the roentgenogram; nor are its diagnostic indications unequivocal, for such changes often occur without increase of pressure. The most pressure

erosions are found in the middle fossa—on the sphenoidal bone and on the pyramids. On the petrous portion of the temporal bone, increase of pressure produces greater acuity of the pyramidal eminence. But increased acuity is not to be regarded as the result of augmented pressure unless it is marked (Fig. 5) or can be observed during the course of development. A very characteristic erosion on the upper margin of the pyramid medial to the eminentia arcuata, at the subarcuate fossa, at the point at which the arteria profunda cerebri crosses the upper margin of the pyramid, is important because it is pathognomonic for increase of pressure. The erosion is distinguishable by its right-angled course, one leg being formed by the portion of the labyrinthian capsule that surrounds the superior semicircular canal, the other by the sclerotic tissue surrounding the internal auditory canal (Fig. 32). In the sagittal general view this

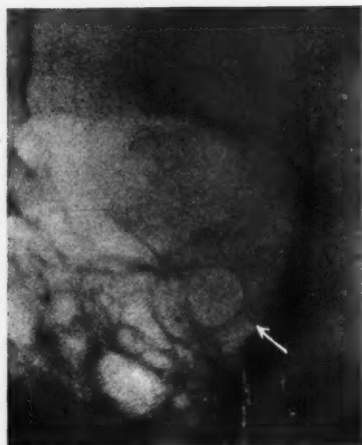


Fig. 8. Roentgenogram of the optic canal, after the method of Rhese-Goalwin. Enormous dilatation due to endocranial increase of pressure.

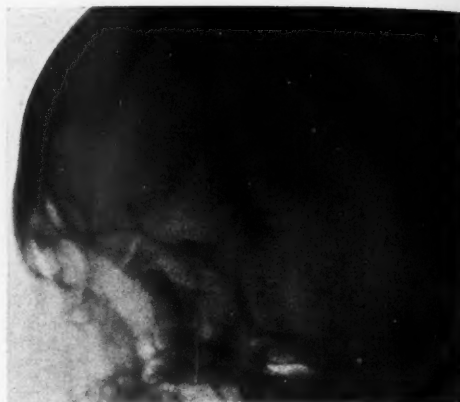


Fig. 9. Lateral view of the anterior fossa. Extensive erosion of its floor. The planum sphenoidale and the roof of one orbit are almost completely lacking. There is marked erosion of the sella turcica, due to pressure.

erosion cannot usually be seen, because when the roentgenogram is taken from this direction it is obscured by the eminentia arcuata. It is shown only in the roentgenogram following the Stenvers method. In the beginning stages only a slight depression at the point described may be seen, as is shown in Figure 5. This manifestation occurs also as a variation, and is therefore not particularly characteristic of increase of pressure. Only when the right-angled shape is pronounced, as in Figure 32, has the finding diagnostic value. Variations in the contour of the upper portion of the pyramid, as revealed by the sagittal general view, must not, without further inquiry, be ascribed to a unilateral erosion. They are usually caused by the fact that the longitudinal axes of the pyramids do not run symmetrically to one another or by the turning of one of the pyramids about its longitudinal axis, so that a different contour is brought into view as forming the margin. Less frequent than changes in the upper margin of the pyramid, we find, associated with endocranial increase of pressure, a dil-

atation of the carotid canal, which is revealed by an irregular translucency on the lower side of the pyramidal eminence, as shown in Figure 6, or in the great wing of the sphenoidal bone a dilatation of the foramina, especially of the foramen lacerum, the foramen ovale, and the foramen rotundum (Fig. 7). However, the diameter of the foramina commonly presents variations within certain limits, and there are also frequently differentiations between the right and the left wings when there is no pathologic finding, for which reason the widening of one of the foramina could not in itself be regarded as evidence of increase of pressure or of a local erosion. For the same reasons, a widening of the fissura orbitalis superior seldom has diagnostic significance. The erosion of the small wing of the sphenoidal bone affects uniformly its posterior margin. In some instances, the optic canal may be involved, in which case it will be greatly enlarged, as shown in Figure 8. Erosions of the anterior cranial fossa, if they are not extensive, often fail to be brought into view by the roentgenologic examination, because its floor, even under normal conditions, is very thin and therefore

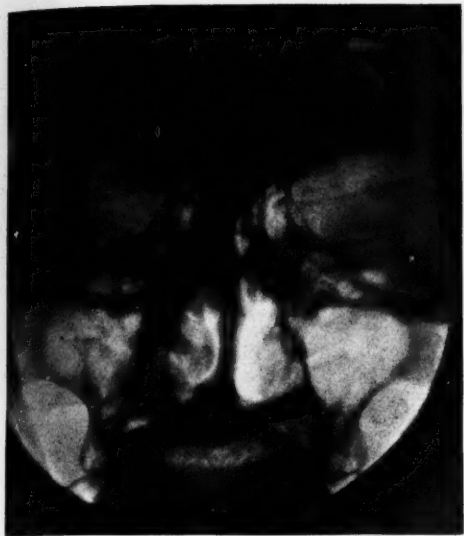


Fig. 10. Slight clouding of the left-sided accessory sinuses, associated with a parasellar tumor of the left side.



Fig. 11. Frontal roentgenogram of the sella turcica. The body of the sphenoidal bone is indistinctly demarcated, and presents many light areas not sharply outlined. The anterior and the posterior clinoid processes are still relatively well preserved. The sphenoidal sinus is partially destroyed and not sharply demarcated. It is a question of either tuberculosis or a sarcoma of the body of the sphenoidal bone.



Sketch II. Normal sella turcica.



Sketch III. Anterior erosion of the dorsum sellae caused by an endosellar tumor.



Sketch IV. Erosion of the dorsum sellae from above, caused by a suprasellar tumor or hydrocephalus of the third ventricle.



Sketch V. Erosion of the dorsum sellae from above and behind, caused by a tumor or hydrocephalus of the third ventricle.

produces only a slight shadow. The small wing of the sphenoidal bone is the most dense, and is not eroded on its posterior border, as is the middle fossa, by increase of

pressure, but rather on the anterior portion. Here a characteristic deepening of the digital impressions may often be distinctly recognized. But it must be remembered that precisely the superior and anterior contour of the small wing of the sphenoidal bone may present widely different appearances, and that it may, in fact, be, under certain circumstances, quite irregular in shape. The thinness of the floor of the anterior cranial fossa furnishes the explanation why, in a comparatively short time, such extensive erosions may be produced in it, as may be seen in Figure 9.

B.—Local Changes Wrought by Tumors

1. *Sella Turcica:* The changes in the sella turcica have been carefully studied, particularly by Schüller. Sketches II, III, IV, V, VI, VII and VIII illustrate, therefore, only a few characteristic erosions of the dorsum sellae, which are of importance for topical diagnosis.

Erosions such as are shown in Sketches

Sketch VI. Posterior erosion of the dorsum sellæ, associated with pontobulbar tumor.



Sketch VII. Posterior erosion of the dorsum sellæ and forward bending of the dorsum, associated with pontobulbar tumor.



Sketch VIII. Erosion of the posterior side of the dorsum sellæ, caused by a malignant, retrosellar tumor.



VI and VIII are not necessarily of pathologic origin. Such an attenuation of the dorsum sellæ or such an irregular appearance of its posterior contour may occasionally be observed in normal cases. That endocranial increase of pressure may produce changes in the sella turcica similar to those caused by an endosellar tumor has already been stated. Parasellar calcifications; for instance, in the internal carotid artery; but, particularly, also exostoses of the anterior clinoid processes, or a spur that frequently projects into the sella turcica, may be taken for intrasellar calcifications such as are sometimes observed in association with endosellar tumors.

The demonstrability of endosellar tumors varies considerably. On the one hand, cases are observed in which, at necropsy, a hypophyseal tumor is revealed that produced unequivocal clinical symptoms, although it could not be demonstrated by roentgenographic methods, while, on the other hand, there are cases in which the tumor was diagnosed by roentgenologic means, as a secondary finding, several months before the first clinical symptoms appeared. In recent years, an attempt has been made to place the roentgenologic diagnosis of conditions in the sella turcica on a more exact basis by

taking, by means of a lateral view, the precise measurements of the surface area of that fossa. This method has, however, a number of serious disadvantages, chiefly by reason of the fact that the sella turcica and the hypophysis cannot be identified. It is, therefore, doubtless better, on the basis of wide experience, to rely on extensive changes than to try to attain exactness by means of precise measurements when the most necessary preconditions are wanting.

Great difficulties are encountered in the roentgenologic diagnosis of parasellar tumors. We have sometimes observed that the dorsum sellæ, if the configuration is normal and sharply outlined, appears only indistinctly as a group of very delicate shadows. If the primary or central bundle of rays was inclined somewhat toward the frontal plane, so that the dorsum sellæ was struck obliquely, it was often scarcely brought into view at all. Thus, it may happen, in such cases, that two roentgenograms of the same patient are made in quick succession, one of which happens to be taken precisely in a frontal direction and the other at a slight inclination to the first, with the result that the first reveals no changes in the sella turcica, whereas the second depicts what is apparently an extensive destruction. If the roentgenogram is taken in a precisely frontal direction, the remainder of the dorsum sellæ gives an approximately normal shadow, whereas, if taken obliquely, it cannot be distinguished at all. The diagnosis "parasellar tumor" may receive substantial support from a circumstance that has hitherto been seldom considered. The impairment of the blood circulation in the cavernous sinus, which such tumors may bring about by compression of the sinus, may, as a result of stasis, produce an edema of the mucous membranes of the ethmoid cells, the maxillary sinus, and the sphenoidal sinus of the same side, and thus cause these to present an indistinct or blurred appearance (Fig. 10). This possibility should always



Fig. 12. Submentovertical roentgenogram of the middle skull base. The healthy side is at the left, and the diseased side is at the right. The arrows at the left designate in the order from top to bottom: (1) the pterygoid process; (2) the foramen ovale, and (3) the foramen spinosum. The arrows at the right designate the irregularly but, at the same time, rather sharply demarcated defect, which was caused by a carcinoma of the epipharynx that emerged into the middle fossa.



Fig. 13. Verticosubmental roentgenogram of the middle fossa. The healthy side is at the right, and the diseased side is at the left. The arrows designate corresponding sites on either side; namely, the anterior border between the pyramid and the great wing of the sphenoidal bone. The borderline at the right is sharply demarcated; at the left it is completely obliterated, the bone there presenting a somewhat lighter shade. We are dealing here with a sarcoma that has emerged from the middle ear in the direction of the nasopharynx and has infiltrated the bone.

be called to mind, especially in those cases in which there is clinical evidence of a retrobulbar neuritis and the roentgenograms show a slight veiling or clouding of the ethmoid cells or the sphenoidal sinus. While it is true that one is ordinarily justified in assuming that an inflammation of the cells and the sinus in question has produced this symptom, yet one must not neglect to recall that a parasellar process in the middle fossa may be causing the veiling.

2. The Body of the Sphenoidal Bone: We can demonstrate changes in the body of the sphenoidal bone only in case the tumor emerges from the bone or from the sphenoidal sinus. To be considered are: either primary sarcomas or metastatic sarcomas or carcinomas. We find, in addition to the veiling or shadowing of the sphenoidal sinus, extensive destruction of the bone. The longer preservation of the upper portions of the sella turcica serves to indicate that the tumor would have its origin in the

body of the sphenoidal bone. The differential diagnosis as between sarcoma and tuberculosis may, in some cases, be difficult or even impossible, for the reason that the focus of destruction in both conditions presents indistinctly limited translucency in the atrophic, infiltrated bone (Fig. 11).

3. The Great Wings of the Sphenoidal Bone: Extensive foci of destruction are produced almost exclusively by malignant tumors, which, developing first in the middle ear or in the nasopharynx and its adjacent tissues, spread to the sphenoidal bone. Such tumors are clearly brought out in the roentgenogram taken in the submentovertical direction. At the same time, we find here, as elsewhere, at the base of the cranium the characteristic differences between the carcinoma and the sarcoma; namely, the irregular but rather sharply limited defect in the former, and diffuse decalcification and indistinct shadows, as the expression of extensive infiltration, in the



Fig. 14 (Above). Sagittal roentgenogram of the orbit. The right orbit shows a thickening of the great and of the small wing of the sphenoidal bone and of the lateral wall of the body of the sphenoidal bone (but not of the lamina papyracea). Diagnosis: Endothelioma of the middle fossa, adjoining the orbit.

Fig. 15 (Below). Sagittal roentgenogram of both orbits. Erosion of the lower margin of the right superior orbital fissure and of the right anterior clinoid process, associated with a tumor of the middle fossa, located behind the orbit adjoining the sella turcica.

latter (Figs. 12 and 13). Endotheliomas of the middle fossa may produce a thickening of the great wing of the sphenoidal bone, which, if it affects the lateral orbital wall, is recognizable in the roentgenogram giving the general view and taken in the

sagittal plane, otherwise in the roentgenogram taken in the axial plane, on comparison with the side that is intact. If the tumor lies against the orbit, it frequently causes a protrusion of the bulbus. If we observe in the general view in the sagittal plane a veiling of the orbit on the side involved, we must raise the question as to whether it is caused by swelling of the soft parts or by changes in the bones. The question is in most cases easily answered. If the shadow is caused by swelling of the soft parts, the contrast between the area of lesser density identifying the superior orbital fissure and the shadow of the surrounding bone, namely, the great and small wing of the sphenoidal bone, will be lessened. If it is produced by bone changes, the opposite will be true; the contrast will more likely be enhanced, but, in any event, not diminished (Fig. 14). Less frequent than such thickening, erosions of the lateral orbital wall may be observed, as shown in Figure 15. They cannot always be diagnosed with certainty, for precisely the lower margin of the superior orbital fissure is exceedingly variable, and, more particularly, the spina musculi recti lateralis may have developed into a projecting prong.

4. *The Small Wings of the Sphenoidal Bone:* The most frequent changes that we find in the small wings of the sphenoidal bone are hyperostoses, caused by adjacent tumors, as shown in Figures 14 and 16. They are analogous to the corresponding changes in the great wings of the sphenoidal bone. If the thickening is demonstrated beyond all doubt, it remains to be decided whether we are dealing with an idiopathic, sclerosing hyperostosis or a secondary sclerosis that, in the last analysis, rests on an inflammatory basis. If the small wing of the sphenoidal bone has become thickened, it commonly loses its slender form and presents a bulgy appearance. But if it is a question of an idiopathic, sclerosing hyper-



Fig. 16. Lateral view of the middle fossa. Hyperostosis of the small wing of the sphenoidal bone associated with endothelioma of the middle fossa. (The same case as Figure 14.)



Fig. 17. Roentgenogram of the optic canal after the method of Rhese-Goalwin. Narrowing and deformation of the canal; above it small, irregular spots showing calcification. Diagnosis: A small psammoma lying within the optic canal.

ostosis, its form remains regular. If the condition is due to a secondary sclerosis, on the other hand—for example, as the result of an adjacent tumor, as shown in Figure 14—its demarcation will be irregular, which can be noted especially on the normally beautifully drawn line of its lower contour, which constitutes the upper border of the superior orbital fissure. Also on the optic canal the change can be readily demonstrated, if it happens to be involved. In idiopathic hyperostosis, a uniform narrowing will have taken place; if it is a matter of secondary sclerosis, in addition to the narrowing, there will be an irregular demarcation (Fig. 17). If we have to do with a process in the middle fossa (endothelioma), we can usually establish by means of the roentgenogram, taken from the frontal point of view, of the sella turcica, a bulginess, a thickening, and an irregular configuration of one of the anterior clinoid processes (Fig. 18). The diameter of the optic canal varies, under normal conditions, between 4 and 5 mm., and may not

be exactly the same on both sides. In its lower portion we observe sometimes, as a variation, the formation of a bridge or of prongs (Fig. 19). This occurs when the ophthalmic artery penetrates the bony plate that separates the optic canal from the superior orbital fissure. Less frequently than hyperostoses we find erosions on the small wing of the sphenoidal bone, which affect then, for the most part, the anterior clinoid process. If, in the roentgenogram of the sella turcica, taken from the lateral angle, the two processes lie one over the other, a unilateral erosion may easily be overlooked. It is advisable, therefore, in general, to arrange the taking of the roentgenogram in such a manner that the two processes are brought separately into view, care being observed that, for such purpose, the base of the central bundle of rays is shifted cephalad and not caudad. Occasionally it may be observed that an anterior clinoid process, analogous to the dorsum sellæ, will be diverted from its normal position by a retrosellar tumor and present not only an erosion

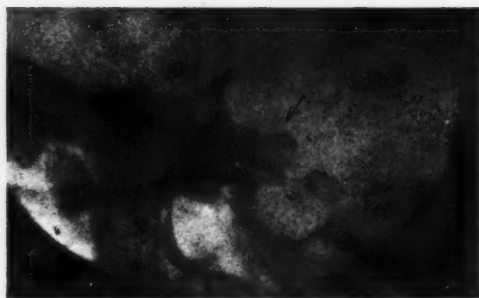


Fig. 18. Lateral roentgenogram of the sella turcica. One anterior clinoid process is thickened, bulgy, and of irregular contour. (The same case as Figure 17.)

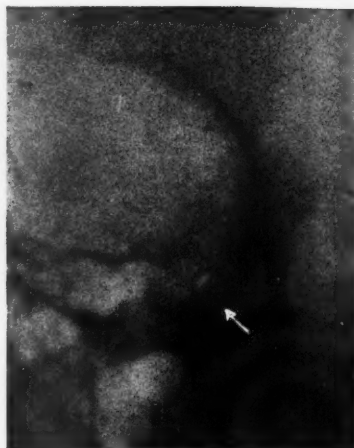


Fig. 19. Roentgenogram of the optic canal after the method of Rhese-Goalwin. Indentation in the lower portion of the optic canal (a variation?).

but also a curvature (Fig. 20). If the two processes show differences in size, the condition is not necessarily due to an erosion. It is observed especially if one of the processes is pneumatized. The pneumatized process is then always the larger. The fact of pneumatization may easily escape notice in the roentgenogram of the sella turcica, taken from the frontal direction, but in the roentgenogram of the orbit, taken after the Rhese method, in an oblique direction, it can be plainly recognized.

5. *The Pyramids:* With respect to the pyramids, we can distinguish rather sharply between those tumors that involve the middle ear spaces and effect changes primarily in the mastoid portion and those that originate in the pyramidal eminence or its vicinity and cause erosions there. The former seldom produce basal symptoms. Sarcomas, however, do occasionally cause such symptoms. But since, in the presence of extensive destruction, other tumors must be considered from the standpoint of differential diagnosis, these also must be discussed. If we find an extensive destruction of the pyramid that evidently relates back to the mastoid portion, the cause of it must be sought in a malignant tumor or in a chronic inflammatory process.

Let us consider first the destructive processes as they develop in the temporal

bone when produced by a malignant tumor. Two types of destructive processes may be distinguished, which, although they may not always present the same characteristic differences, yet, in typical cases, will show such essential differentiation that conclusions as to the nature of the tumor may be based thereon. There are, then, the defects produced by carcinomas, on the one hand, and those caused by sarcomatous tumors, on the other hand. From the anatomicopathologic standpoint, they differ in their mode of dissemination through the fact that the former attack the surrounding bone more vigorously than the latter, which, in general, confine themselves more frequently to existing paths. The roentgenograms of an individual case reflect such behavior. Exceptions to the foregoing rule occur, in that a carcinoma occasionally is confined longer than usual to the existing paths or that a sarcoma attacks the bone more vigorously, but in typical cases we can, with a high degree of probability, establish a differential diagnosis between these two groups of tumors. The carcinoma develops on the basis



Fig. 20. Frontal roentgenogram of the sella turcica. Tumor of the middle fossa adjoining the sella turcica. One anterior clinoid process is narrowed and its posterior end is pressed upward. (The same case as Figure 15.)



Fig. 21. Roentgenogram of the temporal bone after the Stenvers method. Carcinoma of the middle ear. The apex of the pyramid is intact; the pars mastoidea is completely destroyed; in place of the labyrinth there are two somewhat circular lighter areas (local metastases).

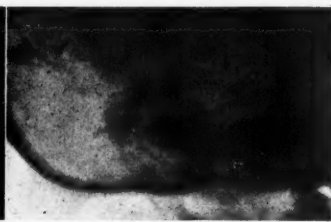


Fig. 22. Roentgenogram of the temporal bone after the Stenvers method. Sarcoma of the middle ear. Of the pyramid only the compact labyrinthine nucleus with the bony labyrinth can be clearly distinguished. The pars mastoidea is entirely destroyed. Of the apex of the pyramid only slight traces can be seen.

of a chronic otitis. In the latter condition, a pneumatization disturbance is the rule, but we often find, even in the presence of a carcinoma, the mastoid portion only slightly pneumatized, or, in fact, not at all. The carcinomatous destruction is, in such cases, to be recognized as such only when, in spite of the slight extent of the process of destruction, the labyrinth is attacked, or local metastases in the form of small, circular foci of destruction appear in it, or if, with extensive destruction, the regular, sharp demarcation, which is characteristic for large cholestatomas, is lacking, though it should be borne in mind that acute exacerbation of the pus formation may produce indistinct demarcation. The conditions are different if a carcinoma develops in a well pneumatized mastoid process. Here two processes run parallel. On the one hand, we have the destruction of the bone; on the other hand, the penetration of the cells by the tumors, whereby the air is expelled from them. We see, therefore, at a certain stage, in addition to a local bone destruction, which we cannot always with certainty declare to be pathologic (for example, if it affects only the immediate vicinity of the antrum), only a diminution of the air content of the cells. The picture may,

in such cases, resemble, to a certain extent, that of acute mastoiditis. As the process continues, more and more of the bone is destroyed, until, finally, also the surfaces that border on the middle and on the posterior fossa are included, and portions of the tumor penetrate the labyrinth with destructive effect. If we find a pyramid in this stage, the whole pars mastoidea, including the lateral portion of the pyramid up to the superior margin of the petrous portion of the temporal bone, does not furnish a distinct shadow, the labyrinth is more or less destroyed, while the medial portion of the pyramid presents a normal appearance. The borderline of the defect is irregular, and unless it is formed by surviving cell walls, it is imperfectly outlined. The condition cannot be taken for an acute mastoiditis, for a mastoiditis cannot develop to such an extent, since the patient would have succumbed earlier, under such circumstances, to the attacks of an inevitable meningitis.

The first stage of development of the carcinoma in a normally pneumatized mastoid process resembles, to a great extent, the changes produced at the outset by sarcomatous tumors. If destruction of the bone occurs, the sarcoma, in spite of advanced growth, leaves the antrum wall (which is

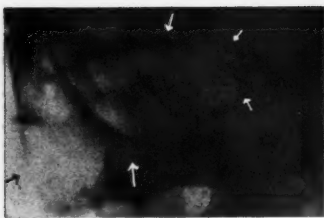


Fig. 23. Roentgenogram of the temporal bone after the Stenvers method. Total destruction of the pars mastoidea and of the pyramid by cholesteatoma. There remain only rather sharply demarcated vestiges of the cortical layer of both.

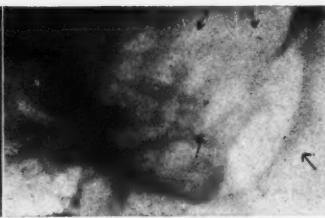


Fig. 24. Roentgenogram of the temporal bone after the Stenvers method. Tuberculous caries of the pars mastoidea and of the pyramid. Both present areas of lesser density. The labyrinth can be distinguished very clearly. It is, however, surrounded by a thin fibrous coat.



Fig. 25. Roentgenogram of the temporal bone after the Stenvers method. Carcinomatous metastasis in the apex of the pyramid, characterized by a defect with large prongs, but, comparatively sharp demarcation.

often somewhat thicker) still intact,—sometimes even if, penetrating the tubes, it has already wrought changes in the pyramidal eminence. Here, too, in the initial stages, there is a certain resemblance to acute mastoiditis. If the destruction is extensive, the diagnosis cannot be uncertain, for the same reasons as mentioned above with reference to carcinoma. In this stage there are also essential differences that permit a differentiation between a carcinoma and a sarcoma. In the case of a sarcoma, the compact bone of the labyrinth remains intact for a long time. It will be observed that the bone not only laterally but also medially to the labyrinth is destroyed, but that the roentgenogram shows that the labyrinth itself is still intact.

There is still another circumstance that points with certainty to the sarcoma as the cause of the destruction. Whereas the carcinoma attacks the bone relentlessly in the region of the planum mastoideum, in case so wide an extension of the tumor occurs, the sarcoma works its way through the bone along the vascular and lymph paths, and gradually lifts the periosteum from the bone along the planum mastoideum. As a reaction to the insult, ossification results. In the course of time, the bone of this region comes to project, a symptom that is characteristic

for sarcomatous tumors. But if such projection is still absent, and if we have only an extensive destruction in the pars mastoidea, or possibly also in the pyramidal eminence, together with a relatively intact condition of the labyrinth, a carcinoma can be ruled out with a high degree of probability and an acute inflammatory process with certainty; however, in such a case, an extensive tuberculous caries would affect the differential diagnosis.

We find, not only in sarcoma but also in tuberculosis, in the roentgenograms made of the two pyramids in a sagittal direction for comparative purposes, an increased permeability to the rays, on the diseased side. A special roentgenogram is necessary to furnish the details on which to base a diagnosis. The main thing to observe is: As soon as the tuberculosis, which always has its primary origin in the mucous membrane of the middle ear spaces, begins to attack the bone, a distinct atrophy thereof develops, on the one hand, unless there should be a mixed infection, and, on the other hand, a uniform dilatation of the antrum and the epitympanic recess will be noted. With the sarcoma conditions are different. Here a destruction of the bone is brought about, owing to invasion by the tumor cells, the intensity of which, as already men-



Fig. 26. Roentgenogram of the temporal bone after the Stenvers method. Sarcoma emerging from the apex of the pyramid. At the site of the pyramid there are only a few indistinct, dense shadows. The labyrinth is also partly destroyed. The structure of the whole pars mastoidea is preserved, but it is much lighter than normal, a sign that it is involved.



Fig. 27. Roentgenogram of the temporal bone after the Stenvers method. Destruction of the apex of the pyramid associated with carcinoma of the epipharynx.

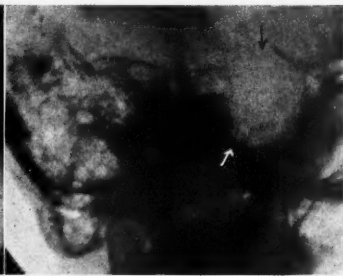


Fig. 28. Roentgenogram of the temporal bone after the Stenvers method. Destruction of the apex of the pyramid as caused by an endothelioma.

tioned, being dependent on the resistance of the healthy tissue. Often the antrum wall is more resistant than that of the cells, so that it resists the attack for some time. In contradistinction to tuberculosis, in which the walls of the antrum are attacked first, we find that in sarcoma the walls are preserved for a comparatively long time, often even when the tumor has penetrated completely the pars mastoidea, and possibly has brought about changes in the pyramidal eminences.

In carcinoma, there is to be considered, from the standpoint of differential diagnosis, also in the presence of extensive destruction, the possibility of a cholesteatoma, which, in rare instances, after destruction of the labyrinth, may advance to the pyramidal eminence. In such cases, the single general view of the pyramids may prove inadequate and may not bring out any distinct difference in their permeability to the roentgen rays, whereas the special roentgenograms give a clear picture of the destruction. The reason for this may lie in the fact that the cholesteatoma is almost always associated with a sclerotic condition of the surrounding bone, whereby the loss of

shadowing occasioned by the defect may be compensated to a certain extent. The cholesteatoma shows, even though the semicircular canals and the cochlea have been destroyed, the same characteristics as large cholesteatomas without acutely exacerbated suppuration; namely, the sharp, smooth, more or less regular demarcation. It is found only in chronic and not in specific otitis. In acute exacerbation of the suppuration the demarcation of the defect becomes, of course, faint and indistinct. However, in connection with a roentgenologic examination, a differential diagnosis in such cases will seldom be necessary, since large cholesteatomas expose extensively the dura of the middle and the posterior fossa and thus, if an acute flare-up of the suppuration occurs, clinically unequivocal symptoms will soon become manifest.

To summarize what we have stated in regard to tumors of the pars mastoidea, the following factors in the differential diagnosis may, on the basis of previous observations, be emphasized as of present interest. In the presence of extensive destruction in the petrous portion of the temporal bone, which evidently has its origin in the pars



Fig. 29. Roentgenogram of the temporal bone after the Stenvers method. Irregular dilatation of the internal auditory canal.

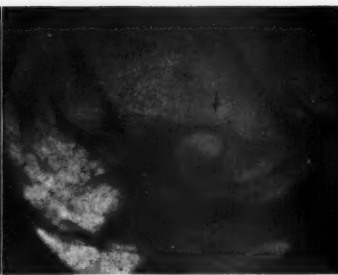


Fig. 30. Roentgenogram of the temporal bone after the Stenvers method. Ogival (bullet-shaped) dilatation of the internal auditory canal by a nodular tumor of the auditory nerve.

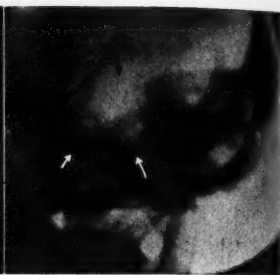


Fig. 31. Roentgenogram of the temporal bone after the Stenvers method. Destruction of the upper and posterior portion of the apex of the pyramid by a tumor of the auditory nerve.

mastoidea, there are four possible conditions to be taken into account: (1) carcinoma, (2) sarcoma, (3) tuberculosis, and (4) cholesteatoma. If the defect is distinctly demarcated with reference to the surrounding tissues, carcinoma or cholesteatoma is the most likely condition present. An irregular and somewhat indistinct demarcation points to carcinoma, while a regular, smooth demarcation is indicative of cholesteatoma. Local metastases furnish evidence for malignant tumor. If the defect is not distinctly demarcated with reference to the surrounding tissues, and the roentgenogram awakens rather the impression of an extensive, diffuse atrophy of the pyramid, sarcoma or tuberculosis is to be considered, especially if, with labyrinth intact, the bone not only medial but also lateral to it shows distinct signs of decalcification. If, however, the wall of the antrum may still be easily recognized, such finding is opposed to the idea of tuberculosis. A forward bulging of the planum mastoideum may be interpreted as evidence for sarcoma (Figs. 21, 22, 23 and 24).

In the presence of erosions at the pyramidal eminence, a roentgenologic examination will furnish reasonably exact information in regard to the nature of the tumor

and its point of origin, for such erosions present very characteristic differences in the various tumors. Carcinomatous metastases in the pyramidal eminence (and this is, so far as the temporal bone is concerned, a seat of election for such metastases) show irregular, large-pronged, but, at the same time, rather sharply demarcated defects (Fig. 25). Sarcomas at this point cause destruction that is not so well demarcated with reference to the adjacent tissues (Fig. 26). In addition, the same thing may be said here that was stated with regard to the tumors of the pars mastoidea—carcinomas attack the compact bone more violently than do sarcomas. Sometimes a destruction of the pyramidal eminence from below occurs through the action of peritubal tumors (Fig. 27). These are either sarcomas that originate in the connective tissue of the tubes or carcinomas that have their origin in the region of the pharyngeal recess. They are characterized by the upwardly convex defect that they produce at the apex of the petrous portion of the temporal bone, which gives the apex the appearance of having been gnawed from below. However, here, as well, the carcinomas have a considerably sharper demarcation.

Benign tumors, which originate in the

dura, when they attack the pyramidal eminence, produce in it sharply and regularly demarcated defects, which, for the most part, are bordered by a diagonal line extending from the outer margin at the top to the interior below or sometimes by a vertical line (Fig. 28). In rare cases, hypophyseal tumors extend to the pyramid and destroy the apex. According to the observations of the pathologic anatomists, which accord with our own, these tumors, if their growth is asymmetrical, almost always attack, strange to say, the right pyramidal eminence. Most commonly, erosions are produced in the apex of the petrous portion of the temporal bone by pontobulbar tumors, which develop in the recess between the pons, the medulla oblongata, and the cerebellum. Such tumors are almost always neuromas, fibromas, or sarcomas, which emerge from the auditory nerve. They often extend into the internal auditory canal as so many cones, and thus bring about at times an irregular dilatation of the meatus (Fig. 29). In other cases, we find at the site of the internal auditory canal a sharply demarcated, circular and entirely regular area of translucency. If the bone is destroyed for a considerable extent, which is the case especially in malignant tumors of the auditory nerve, the destruction affects the posterior and upper portion of the apex of the pyramid (Fig. 31). In that case, we shall be unable to distinguish the internal auditory canal; the cochlea, on the other hand, will be found preserved—at least, in part. If the surface adjoining the defect does not lie in the direction of the rays, the defect with relation to the pyramid will present a double contour. The upper contour will correspond to the erosion on the anterior surface of the pyramid, and the lower and lateral contour will correspond to the erosion of the posterior surface. A deep depression of the trigeminal nerve must not be taken for an erosion of the apex of the pyramid

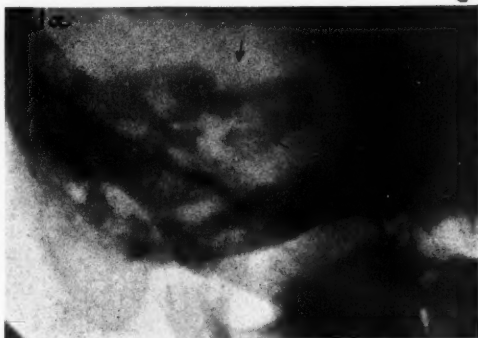


Fig. 32. Roentgenogram of the temporal bone after the Stenvers method. A typical pressure erosion of the upper margin of the pyramid. Destruction of the cochlea and of the vestibule with anterior opening up of the internal auditory canal, caused by a sarcomatous endothelioma.

caused by a tumor. Such a depression is usually symmetrical. A symmetrical hypophyseal tumor may, to be sure, present a similar picture. A complete or partial bridging of the depression by a spicule of bone or a spur has nothing to do with a tumor, but may possibly be associated etiologically with a trigeminal neuralgia. A dilatation of the internal auditory canal may be of congenital origin and no further pathologic changes may be demonstrable. In such cases, the manifestation will always be bilateral. It is important to note that it may happen, in connection with tumors of the auditory nerve, that the internal auditory canal of the intact side is dilated, whereas the meatus of the pathologic side presents normal dimensions. In such cases, we may possibly assume that the tumor occupying the internal auditory canal not only failed to cause dilatation but even protected it against dilatation as a result of increased pressure, which, however, affected the other, the sound side. Otherwise, such a finding is hard to understand. In the frequently employed roentgenogram after the Schüller method, we see within the translucent area representing the internal auditory canal a star-shaped shadow, which is formed by the

crista transversa and the posterior, lateral portion of the cochlear capsule. In the presence of an erosion of the internal auditory canal, even they may be destroyed, and there remains in the Schüller roentgenogram, at the same spot, a sharply demarcated less dense area, which is produced, for the most part, by the cochlea but which may be taken for the internal auditory canal. However, instead of being divided into three parts by the star-shaped bone spicule, we find it cut in two by a vertical strip formed by the bone separating the vestibule and the cochlea. The absence of the star has in itself no diagnostic significance, since sometimes, even in normal roentgenograms, it is not brought into view. The typical erosion demarcated by an upward convexity, occurring in peritubal tumors, may be simulated by a large foramen lacerum or a large carotid canal. A similar deception may result also from incorrect projection, whereby the foramen magnum overlaps the pyramidal eminence, so that, at that site, a translucency demarcated by an upward convexity occurs. In the case of the sagittal general roentgenogram, the same erroneous conclusion may be reached if a maxillary sinus that projects far into the orbital region overlaps the lower portion of a pyramidal eminence and the thereby resulting area of lesser density simulates a defect. Large islands of substantia spongiosa in the apex of the petrous portion of the temporal bone or pneumatic cells in the apex must not be taken for destructive foci. The spongiosa islands will usually show distinct spongiosa markings, if the roentgenogram is taken with the proper technic. The cells that are found in rare cases in the pyramidal eminence give always an especially marked lighter area with a curved demarcation, which is formed by a delicate but distinct cortical layer. Moreover, such small destructive foci could not produce clinical symptoms. If, in taking

the roentgenogram of the temporal bone, after the Stenvers method, a very thin portion of the occipital bone (very often the lower quadrants of the occiput, especially in the aged, are exceedingly thin) happens to overlap the pars mastoidea, the upper contour of the pyramid in the lateral portion may be, as it were, carried away by inadvertent over-exposure of the narrowly circumscribed region, and an extensive defect, such as we find in association with malignant tumors, may be simulated.

From what has been stated, it is evident that, in the presence of tumors, we can demonstrate the destruction in the temporal bone, at first, either in the pars mastoidea or in the apex of the petrous portion. In very rare cases we find the first signs of the tumors in the middle portions, more particularly in the tympanic cavity and the labyrinthine nucleus. We are concerned here either with benign tumors, which will not be discussed at length as they do not cause basal symptoms, or with tumors that come next in order toward the malignant side, namely, endotheliomas, which occupy a midposition between benign and malignant tumors. They behave sometimes precisely like sarcomas, and again, but more rarely, like carcinomas, in which case they cannot by roentgenologic methods be differentiated from carcinomas. As a rule, however, they are less malignant, and produce, then, characteristic symptoms. They attack the bone in the same manner as malignant tumors, but they act more slowly. They cause erosions, in the same manner as a carcinoma, in the densely sclerotic, compact labyrinthine nucleus, but the changes that they produce are much more localized than those occasioned by malignant tumors. For instance, Figure 32 shows a sarcomatous endothelioma that has completely destroyed the medial wall of the tympanic cavity without having caused any essential changes

in the pneumatic system or the pyramidal eminence. If the destruction has advanced so far as in our case, in which there is sure evidence as to the endocranial site of the tumor, it is no longer possible to decide whether the tumor emerged from the dura of the middle fossa and penetrated secondarily the tympanic cavity, or whether, on the contrary, the tympanic cavity was the primary site. Endotheliomas of the tympanic cavity are, to be sure, exceedingly rare, but there are unequivocal instances of their having been observed.

6. *The Clivus*: Change in the clivus is difficult to demonstrate, first, because of its high degree of permeability to roentgen rays, and, secondly, because of its being overlapped by the pyramids in roentgenograms taken from a lateral direction, and hence has seldom been observed. Even in cases in which the body of the sphenoid and the pyramids have been extensively destroyed, the destruction in the clivus can scarcely be demonstrated.

7. *The Squama*: In the squama we can observe local changes (thinning process) or hyperostoses analogous to the changes in the convexity of the cranium. These findings are, however, rather rare.

8. *The Frontal Bone*: Of the frontal bone the same may be said as of the squama. Hyperostoses and thinning of the bone occur but are rare findings.

TECHNIC OF THE EXAMINATION AND THE PRINCIPAL CHANGES TO BE OBSERVED AS CAUSED BY TUMORS IN VARIOUS SITES

What has been hereinbefore presented in regard to the method of examination in general practice may be thus summarized:

- I. Suspected tumor of the posterior fossa:
 - A. *Technic of examination.*
 1. The lateral general roentgenogram (survey).

2. The sagittal general roentgenogram (survey) (anteroposterior).
3. Roentgenogram of the temporal bone after the Stenvers method.
- B. Important changes from the standpoint of diagnosis.
 1. Changes due to increase of pressure:
 - a. Thinning of the squama.
 - b. Dilatation of the internal auditory canals
 - c. Dilatation of the sella turcica, associated with hydrocephalus of the third ventricle.
 2. Local changes caused by the tumor:
 - a. Thinnings or hyperostoses of the squama.
 - b. Dilatation of the internal auditory canal.
 - c. Erosion of the apex of the pyramid.
 - d. Erosion of the dorsum sellæ.

II. Suspected tumor of the middle fossa:

- A. *Technic of examination.*
 1. Lateral general roentgenograms (surveys).
 2. Sagittal general roentgenograms (surveys) (postero-anterior).
 3. Roentgenogram of the temporal bone after the Stenvers method.
- B. Important changes from the standpoint of diagnosis.
 1. Changes due to increase of pressure:
 - a. Dilatation of the sella turcica, associated with hydrocephalus of the third ventricle.
 - b. Acumination of the apex of the pyramid.
 - c. Erosion of the subarcuate fossa.

- d. Erosion of the small wing of the sphenoidal bone.
 - e. Widening of the foramina.
 2. Local changes caused by the tumor:
 - a. Erosion of the body of the sphenoidal bone (sella turcica).
 - b. Erosion of the pyramid.
 - c. Erosion of the thickened portion of the great wing of the sphenoidal bone.
 - d. Erosion of the thickened portion of the small wing of the sphenoidal bone.
 3. Obscuration of the ethmoid cells or the sphenoidal sinus.
- III. Suspected tumor of the anterior cranial cavity:
- A. Technic of examination.
 1. The lateral general roentgenogram (survey).
 2. The sagittal general roentgenogram (survey) (postero-anterior).
 3. Roentgenogram of the orbit after the Rhese-Goalwin method.
 - B. Important changes from the standpoint of diagnosis.
 1. Changes due to increase of pressure:
 - a. Dilatation of the sella turcica, associated with hydrocephalus of the third ventricle.
 - b. Pressure erosions of the small wing of the sphenoidal bone and of the frontal bone.
 2. Local changes caused by the tumor:
 - a. Erosions and hyperostoses of the small wing of the sphenoidal bone (optic canal).
 - b. Erosions and hyperostoses of the frontal bone.

The adjoined table of the cases illustrated in this article (pages 339-341) is to show the value of the roentgenologic examination.

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SURVEY OF ILLUSTRATIONS

Figure Number	Clinical Diagnosis	Roentgenologic Diagnosis	Verification (?)
3	Tumor cerebri (?) Encephalitis (?)	Hydrocephalus of third ventricle, probably retrosellar tumor.	In its further development, tumor cerebri.
4	Ménière's disease.	Increase of pressure in the posterior fossa.	Necropsy report: tumor of cerebellum.
5	Tumor cerebri.	Tumor of the middle fossa.	By necropsy.
6	Tumor cerebri (?)	Endocranial increase of pressure; aneurysm of the internal carotid artery (?)	Necropsy report: tumor of the hemisphere.
7, 32	Tumor of the middle ear.	Tumor of the middle fossa and the tympanic cavity, probably a malignant endo-thelioma.	On basis of excised material: endothelioma-like sarcoma.
8	Hydrocephalus.	Hydrocephalus.	
9	Tumor cerebri.	Tumor of frontal brain.	None.
10	Lues cerebri.	Tumor of the middle fossa.	Confirmed by further development.

SURVEY OF ILLUSTRATIONS—*Continued*

Figure Number	Clinical Diagnosis	Roentgenologic Diagnosis	Verification (?)
11	Amaurosis.	Tuberculosis or sarcoma of the body of the sphenoidal bone.	None; roentgenologic finding unequivocal.
12	Carcinoma of the epipharynx; eruption into the middle fossa.	Carcinomatous defect on the floor of the middle fossa.	By necropsy.
13	Sarcoma of the middle ear.	Infiltration of the floor of the middle fossa.	By necropsy.
14, 16	Retrobulbar process.	Tumor of the middle fossa.	None; roentgenologic finding unequivocal.
15, 20	Syphilis.	Tumor of the middle fossa.	By the further development.
17, 18	Retrobulbar neuritis.	Psammoma at the inner end of the optic canal.	Roentgenologic finding unequivocal. Opening of ethmoid bone gave normal finding. In its later course, atrophy of optic nerve.
21	Subacute otitis media.	Carcinoma of the middle ear.	By operation.
22	Tumor parotidis.	Sarcoma of temporal bone.	None.
23	Tuberculosis or tumor of the temporal bone.	Cholesteatoma.	By operation.
24	Caries of the temporal bone.	Caries of the temporal bone.	By operation.
25	Post-traumatic paresis of sixth cranial nerve.	Carcinoma metastasis in apex of the pyramid.	By necropsy.
26	Tumor of the temporal bone.	Sarcoma of the temporal bone.	By excision of test material.
27	Paresis of sixth cranial; negative otologic finding.	Carcinoma of epipharynx.	By excision of test material.
28	Pontobulbar tumor.	Endothelioma.	None.

SURVEY OF ILLUSTRATIONS—*Concluded*

Figure Number	Clinical Diagnosis	Roentgenologic Diagnosis	Verification (?)
29	Tumor of acoustic nerve.	Tumor of acoustic nerve.	By the further development.
30	Paresis of sixth cranial, left; exclusion of vestibular and cochlear, right.	Tumor of acoustic nerve(?) Basal neurofibromatosis.	None.
31	Pontobulbar tumor.	Tumor of acoustic nerve.	By necropsy.

CASE REPORT

PANCREATIC LITHIASIS

REPORT OF CASE, WITH AUTOPSY FINDINGS

By GEORGE H. HESS, M.D.
Roentgenologist Uniontown General Hospital
UNIONTOWN, PA.

In 1902, Kinnicutt, after a careful search of the literature, was able to find only six cases in which a positive diagnosis of pancreatic lithiasis was made or suspected during life. Sistrunk, in 1921, reported four cases of pancreatic stone in which operation had been performed at the Mayo Clinic. Seeger, in 1925, after an extensive search of the literature, reported finding 100 cases, one of which was his own. He reviewed the literature and analyzed the symptoms in 22 of these cases.

Pain was of a variable character, constant, intermittent or colicky, with radiation in various directions. Glycosuria occurred only twice, and, as others have found it more frequently, Seeger considered it a late complication. Jaundice was not uncommon. He emphasized the difficulty of making a diagnosis, even after exploration. In three cases the roentgen ray revealed the calculi.

Hartman, in 1925, summarized the symptoms of the 22 cases abstracted by Seeger and Sistrunk as follows: *Pain* was not mentioned in three cases, was noted as absent in two, mentioned in six, called severe in ten. It radiated to the back in nine and was localized in the epigastrium or hypochondriac areas with one exception, when it occurred in the left lateral area, with downward radiation. *Jaundice* was not spoken of in six, absent in nine, very severe in three, and was noted as present in seven. *Gallstones* were not mentioned in five, were noted as absent in fourteen, and present in three. *Glycosuria* was present in two, noted as absent in fifteen, and not mentioned in

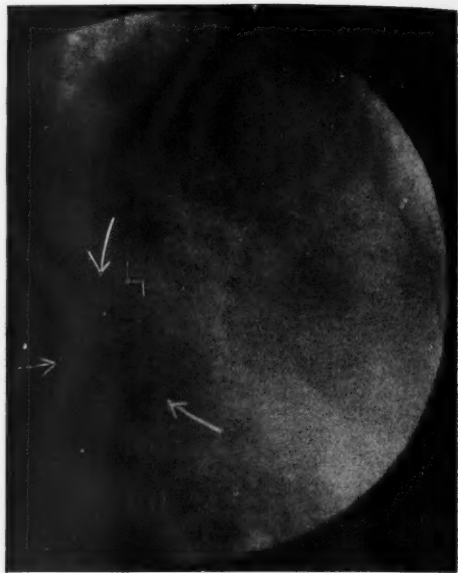


Fig. 1. Radiograph made before operation, showing circumscribed areas of density in gall-bladder area which were thought to be gallstones.

five. *Weight loss* was not mentioned in fourteen, noted as moderate in five, and as marked in three. *Vomiting* occurred in only two cases.

Since Sistrunk's report in 1921 there have been four cases of pancreatic stone demonstrated at operation at the Mayo Clinic. Five other cases were suspected clinically but were not confirmed by operation or X-ray.

CASE REPORT

Patient was white male, aged 40, who was referred for X-ray examination of gastro-intestinal tract March 1, 1923, with the following history. Attacks of indigestion for past four or five years. These attacks consisted of very severe, sharp, cutting pains in the pit of the stomach, going through to the back and accompanied by

vomiting and gaseous distention, the latter being especially distressing after eating. Bowels always regular. In the patient's past medical history he had had pneumonia in 1911, recovering with no compli-



Fig. 2. Radiograph made after operation, showing chain of circumscribed areas of density trailing across epigastric region; diagnosed as calculi in pancreas.

cations. At the age of 19 he had had typhoid fever but made an uneventful recovery, with no sequelæ. As to his family history, his father and mother are living and well, one sister living and well; first wife died of pulmonary tuberculosis, leaving two children, who, although not robust looking are apparently healthy.

Physical examination was essentially negative except for slight tenderness upon deep pressure over gall-bladder area. There was no jaundice. His blood pressure was 120 systolic and 80 diastolic. His weight was 165 pounds—he stated that he had never weighed over 180. Urine was normal except for a low specific gravity, 1.007. Roentgen-ray examination of stomach was

negative except for a small amount of six-hour retention. Forty-eight-hour radiographs showed rather long, twisted appendix which was adherent, and, following free catharsis, remained filled. In the gall-bladder area were many small densities resembling biliary calculi (Fig. 1).

Exploratory operation was performed March 25, 1923, twenty-five days after X-ray examination. The blood at this time showed 4,000,000 red cells, 80 per cent hemoglobin, 10,000 white cells, 70 per cent of which were polymorphonuclears. The urine was still normal except for its low specific gravity.

Operative findings: Gall bladder was enlarged, adherent, showed well marked chronic inflammation, but contained no calculi. It was removed. The appendix was found adherent, twisted upon itself and filled with concretions. It was removed. No other pathology was found.

Patient made an uneventful recovery, temperature never going above 99°, with pulse ranging between 70 and 96. The urine showed a small amount of albumin, acetone, and diacetic acid on the second and third days after the operation and then returned to normal and remained so during convalescence. He was discharged from the hospital April 7, 1923, eleven days after operation.

Desiring an explanation of the shadows appearing on the plate in the gall-bladder area, the patient was returned for further X-ray examination on May 4, 1923, approximately one month after being discharged from the hospital. Films made in the antero-posterior-anterior position revealed not only the localized densities in the right hypochondrium, as before, but a complete chain of such densities trailing across the upper abdomen (Fig. 2). In my previous examination these shadows had been obscured by the barium meal, consequently they were not reported in the gastro-intes-



Fig. 3. Radiograph made of entire pancreas after its removal at autopsy. Note large cyst in head, with constriction through body and dense fibrosis with innumerable calculi.



Fig. 4. Radiograph of same specimen as Figure 3 after longitudinal incision.

tinal examination. As a result of this second X-ray examination a diagnosis of pancreatic lithiasis was made.

The patient continued to do well, although he has never regained his former weight. The attacks of epigastric pain and vomiting ceased and to all indications he was physically well. About five months following operation sugar began appearing in the urine. With the proper use of insulin and regulation of diet, however, he was able to carry on his real estate and insurance business, even though he was not one who would conform strictly to the diabetic rules, being prone to periodic alcoholic "sprees" lasting several days. During the last year he was more or less constantly under the influence of alcohol.

On June 29, 1927, approximately four

years following his operation, he spent the greater part of the day drinking, while on a motor trip of some thirty or forty miles. Returning home in the evening he complained of feeling very tired and lay down on a couch and was soon fast asleep, but when his family attempted to arouse him they were unable to do so, and, becoming alarmed, called the attending physician. As the man's blood sugar the preceding week had been 315 mg. to 100 c.c., the physician believed that the patient was suffering from diabetic coma and administered 60 units of insulin and had him sent at once to the hospital. Blood sugar test made upon his arrival at the hospital showed it to be 13 mg. to 100 c.c. The patient was in profound shock ~~and respirations were reduced~~ to four per minute. Immediately 90 grams

of dextrose was given intravenously and in a short period the respirations returned to normal and the blood sugar to 168 mg. to 100 c.c. The patient, however, became violently delirious, requiring restraint, and died without having regained consciousness.



Fig. 5. Microscopic appearance of decalcified tissue.

Autopsy Findings: A healed operative incision is found in the right upper quadrant of the abdomen. The gall bladder has been removed. All the organs of the thorax and abdomen are apparently normal, with the exception of the pancreas, which is firmly bound to the neighboring organs by fibrous adhesions. The organ was removed and found to weigh 190 grams. It is ovoid in shape, with a constriction in the middle, the greater diameter being 12 cm. and the lesser $4\frac{1}{2}$ cm., while the constricted portion is $2\frac{1}{2}$ cm. The part corresponding to the head of the pancreas has a smooth, rounded surface and on incision is found to consist of a fibrous wall having an average thickness of about 5 mm., in which many very hard calculi are lodged. This wall contains about 15 c.c. of cloudy white liquid in which

about 100 irregularly shaped calculi, less than 5 mm. in diameter, are found. The other half of the organ has an irregular, nodular surface and, on dissection, is found to consist of soft white tissue in which ducts with diameters up to 3 mm. and encrusted with concretion, are seen. (Figures 3 and 4 show radiographs made of specimen after removal and dissection.)

Microscopic sections, prepared from various portions of the specimen after decalcification, failed to reveal any structure that resembled pancreatic tissue, a dense, white, fibrous connective tissue matrix, fairly rich in cells, being the most common structure seen. In this tissue are many masses of granular mononuclear cells, the matrix in these regions being necrotic. No tubercle formation can be found. A Ziehl-Neelson stain of a smear from the wall of the large cyst reveals few degenerated cells but no tubercle bacilli. (Figure 5 shows microscopic appearance of decalcified tissue.)

Pathologic Diagnosis: Pancreatic lithiasis, chronic pancreatitis, with destruction of parenchymatous tissue and cyst formation.

CONCLUSIONS

Few authentic cases of pancreatic lithiasis have been reported in the literature.

No definite clinical symptoms can be presented. The gastro-intestinal disturbances, with periodic attacks of pain in this case, can be explained by the gall bladder and appendix pathology, especially since the symptoms did not return following their removal.

Diagnosis must be made on the roentgen findings plus a hyperglycemia and glycosuria. In the presence of gall-bladder pathology it may not be discovered or even suspected at operation.

An individual may live and continue to enjoy good health with an apparently functionless pancreas. The duration of life, of course, depends upon the proper use of insulin and regulation of diet and exercise.

Insulin is a dangerous drug and must be used with caution. A sudden hypoglycemia from the excessive use of insulin may be more surely fatal than a hyperglycemia, as the latter usually comes on more slowly, giving the organism a chance to adjust itself, as it were, to the high percentage of sugar in the blood stream.

I wish to express my appreciation to Dr. J. S. Hackney for the privilege of reporting this case and to Dr. H. A. Heise for the pathological data.

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Roentgenological Examination of the Gall Bladder. Evarts A. Graham. *Can. Med. Assn. Jour.*, September, 1927, XVII, 1019.

This paper is a contribution to a symposium on the general subject of gall-bladder disease, given before the annual meeting of the Canadian Medical Association. The author limits his discussion of the use of the X-ray in gall-bladder diagnosis to the modern method known as cholecystography. This is essentially a functional test of the gall bladder, and, to a lesser extent, of the biliary system.

Failure to get a gall-bladder shadow by the use of the dye may be due to a damaged liver or to blocking of the cystic duct or to inability of the gall bladder to concentrate its contents. The latter is the most common cause.

Since impairment of the function of concentration is one of the early results of gall blad-

der disease, and since the dye test shows that early impairment, cholecystography is of the greatest value in the early diagnosis of gall-bladder pathology.

Such early impairment of the function of concentration may antedate the onset of a definite cholecystitis; hence the dye test is capable of arriving at a diagnosis of derangement of gall-bladder function before there is any demonstrable organic disease. Therefore, the radiologist is capable of arriving at a diagnosis of "cholecystopathy," and thus of recommending treatment which may obviate the development of a subsequent cholecystitis.

Impairment of liver function is but a rare cause of failure of visualization of the gall-bladder shadow, since a rather excessive amount of damage to the liver is necessary to interfere much with the secretion of the dye.

L. J. CARTER, M.D.

EDITORIAL

M. J. HUBENY, M.D. *Editor*
BENJAMIN H. ORNDOFF, M.D. } *Associate Editors*
JOHN D. CAMP, M.D. }

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THE X-RAY AND PNEUMOTHORAX

The diagnostic value of the X-ray as an aid in determining pathologic conditions within the thoracic cavity is generally conceded. With the passage of time and the multiplication of experiences, doubt, speculation, and conjecture have given place to positive knowledge. Much that was vague and undetermined has been clarified through the researches of competent and intelligent investigators, and in no instance is this more evident than in the determination of pathologic conditions of the pulmonary structure, especially pulmonary tuberculosis. Much of the confusion in the past—nor is it all in the past—has resulted from variations in methods of interpretation of different operators. However, with the adoption by all operators of standard methods and the use of a common language, two of the most frequent causes of dissension and dissatisfaction will have been removed.

Recently we have had occasion to review a number of papers dealing with pulmonary diseases from the clinical and X-ray viewpoints, and we were impressed with the reliance which the clinician has come to place upon the X-ray, from both the standpoints of diagnosis and prognosis. This is well brought out in a paper by Bissell (*Jour. Am. Med. Assn.*, Sept. 17, 1927, LXXXIX, 936). In this article he directs attention to

the exudative type of pulmonary tuberculosis. We quote: "In the exudative type, which the experienced roentgenologist recognizes by the densely homogeneous areas replacing the normal lung, . . . these changes are often precursors of caseation and cavitation." And we would add, further, of adhesions, which often effectively prevent the satisfactory collapse of the lung in attempted compression. We venture to suggest that, if pulmonary collapse were induced at the time the roentgenologic plates revealed the progressive exudative type of tuberculosis, in which the ulcerative processes were rapidly outstripping the formation of connective tissue, failures to secure a satisfactory compression would be reduced to an almost negligible number, the therapeutic value of this measure would be greatly enhanced, and thoracoplastic operations correspondingly reduced.

When artificial pneumothorax was first introduced it was reserved for those advanced cases that had resisted the usual, recognized methods of treatment and that seemed destined for early dissolution. Pneumothorax was then undertaken as a last resort. The results, even under these circumstances, were sometimes surprisingly helpful, and there are not a few patients who frankly attribute their restoration to health to this measure.

We believe we sense a growing tendency on the part of phthisiotherapists to resort to the introduction of pneumothorax earlier than was formerly considered advisable, but the difficulty comes in determining just how early in the course of the disease this should be done. They feel that they should wait until the efficacy of more conservative measures has proved futile. Unfortunately, be-

cause of the lack of a definite basis for determining the better course, they sometimes wait too long. If we may presume without offense and allowing for exceptions selected with intelligent discrimination, and with true value given to all factors bearing thereon, we make bold to suggest that those cases of pulmonary tuberculosis which show a predominantly caseating course, with little or no formation of fibrous tissue following closely upon the progressing field, and not yielding—say, within three months—to hygienic methods as revealed by serial X-ray films, be promptly placed under artificial pneumothorax. We know of a physician, specializing in tuberculosis, who has been following this course for several years. His results, as we have seen them, have been surprisingly satisfactory.

In short, we believe that artificial pneumothorax could be exhibited much earlier than is now generally done, and that the roentgenologist can be of the utmost assistance in aiding the clinician to arrive at a decision.

WILSON RUFFIN ABBOTT, M.D.

RESOLUTION

(FROM THE MINUTES OF THE MEETING)

DR. ERSKINE: I want to present the following resolution:

BE IT RESOLVED that the Radiological Society of North America recommend for the consideration of the Director of the United States Bureau of Standards the following program of X-ray standardization and study of protection, with the necessary appropriations:

A. The standardization of X-ray energy according to the definition of the X-ray unit as recommended by the United States Bureau of Standards; the standardization to be made with the use of a constant potential generator of at least 200 K.V. with the smallest possible percentage of ripple.

(This is the only method accepted by the foreign laboratories.)

B. The publication and distribution of the information obtained.

C. The interchecking of the standard unit with other laboratories and hospitals in order that there may be devised an instrument capable of transportation without loss of calibration.

D. A system under the auspices of the United States Bureau of Standards, of inspection, testing, and recommendations for all laboratories, clinics, and hospitals, according to a fixed code to be established.

E. A program for any other research or investigation pertaining to the general problem of X-ray dosage.

F. The employment of sufficient semi-technical assistance to insure that this program be conducted with least delay and greatest efficiency.

G. The deputation of a representative of the United States Bureau of Standards to the International Congress of Radiology in Stockholm, Sweden, in July, 1928.

The Radiological Society of North America endorses heartily the outline of program as tentatively suggested by the United States Bureau of Standards.

The Radiological Society of North America also offers at any time its full cooperation and assistance to the United States Bureau of Standards for the furtherment of its general X-ray program.

DR. ERSKINE: I move you, Mr. President, that this resolution be adopted and a copy sent to the Director of the Bureau of Standards.

The motion was seconded and unanimously adopted.

COMING GERMAN CONGRESSES

Word has been received of two coming meetings, both important to roentgenology in Germany, and, by extension, to the whole scientific world, that recognizes no political

boundaries. The Nineteenth Congress of the Deutsche Röntgengesellschaft meets at Berlin on April 15, 1928, and the Gesellschaft der Anglo-Naturforschung meets at Hamburg from September 16 to 21, 1928.

SECOND INTERNATIONAL CONGRESS OF RADIOLOGY

EXHIBITION OF RADIOLOGICAL LITERATURE

As an important supplement to the transactions of the Congress relating especially to instruction in medical radiology, the committee of the Congress has decided to arrange a literary exhibition on the Congress premises in the House of Parliament. This exhibition will comprise all textbooks and handbooks on roentgen diagnosis, roentgen therapy, radium therapy, heliotherapy, medical electrology and radiophysics published during the last five years and also the latest complete volumes of all radiological journals.

The Congress committee has much pleasure in inviting publishers to participate in this literary exhibition.

Aktiebolaget Nordiska Bokhandeln, in Stockholm, has kindly undertaken to arrange this exhibition and will also be at the service of those members of the Congress who may wish to order books or journals.

GÖSTA FORSSELL, M.D.

President.

AXEL RENANDER, M.D.

Secretary-General.

COLLEGE FELLOWSHIPS

The American College of Radiology has bestowed upon Professor Claude V. Régaud, of Paris, and Professor Hermann Wintz, of Erlangen, Germany, Honorary Fellowships, for their eminence and accomplishments in radiology.

INSTRUCTION AND TRAINING IN MEDICAL RADIOLOGY:

THE MAIN SUBJECT OF THE SECOND INTERNATIONAL CONGRESS OF RADIOLOGY, STOCKHOLM, 1928

In radiant energy, medicine has found a means for diagnosis and therapy which has become indispensable for the healing art, and which is growing in importance every day. Through research and systematic elaboration of acquired experience, roentgen diagnostics—no less than radiotherapy—has developed into an extensive scientific specialty with its own working methods. In practical medicine, radiology has, in fact, acquired a secure position as an independent system, with its own institutions, led by specially trained radiologists. While medical radiology has been developing and greater and greater tasks have been allotted to it, it has become clear to the representatives of practical medicine—no less than to the universities—that thorough special instruction and training in medical radiology are essential, not only to those intending to devote themselves entirely to it but also to specialists in different branches of medicine to whom radiology will constitute a necessary accessory science. The conviction that a survey of medical radiology should also be included in the general medical curriculum has more and more gained in force.

The organization of the instruction, however, has not in all countries kept pace with the development of radiology in medicine, and the question of suitable forms of instruction and training in this science is everywhere on the program.

The Executive Committee of the Second International Congress of Radiology, to be held in Stockholm, July 23 to 27, inclusive, has therefore resolved to take up *instruction and training in medical radiology* as the main subject of the Congress, medical radiology to include roentgen diagnostics

and radiotherapy, with the sub-divisions, roentgen-, radium-, and heliotherapy.

Primarily the Committee decided to invite a few representatives only from some of the largest radiological societies to set forth their experience gained on this question and to make suggestions for the organization of the teaching and special training in medical radiology.

No sooner did it become known, however, that the question of instruction and training in radiology would be taken up at the Congress than a wish was expressed from different quarters that the Congress should take up this great problem as extensively and completely as possible. This question of instruction is evidently acute in all countries where radiology has reached a certain degree of development. The teaching, however, must necessarily assume different forms of organization in different centers, according to, *inter alia*, the existing organization of medical instruction and hospital service, as well as financial means.

We have, therefore, considered it advisable that the question of teaching should be taken up on a wider basis and that the Congress should collect instructive material concerning radiological teaching in the whole world. We have thought the best possible result to be attained by inviting a lecturer on medical radiology from each of those countries where organized instruction in medical radiology is known to exist, to give a short account of the historical development of the present organization of radiological teaching and training in the country from which he comes, and to put forward views and suggestions for the organization of instruction and training in medical radiology for students as well as for those wishing to take up special branches of radiology.

All these papers will be published immediately after the Congress as a separate volume of the proceedings and will constitute an important source of information

and a stimulus for all those teachers and authorities responsible for the organization and further development of radiological teaching.

At a common session immediately after the inauguration of the Congress brief extracts—not exceeding fifteen minutes—of as many of these papers as time will permit, will be read. The Committee reserves the right to decide the order of these oral extracts and to limit their number.

By the arrangement suggested the question of radiological teaching is likely to be elucidated as extensively and thoroughly as possible. Time will not permit of any discussion after these papers. However, to give others beside those specially invited to speak on the subject an opportunity of bringing forth their views on the organization of radiological teaching, written contributions to the discussion in English, French, or German, not exceeding one octavo page (400 words), will be accepted and published in the special volume of the proceedings, if received, at the latest, on the closing day of the Congress.

GÖSTA FORSELL, M.D.
President.

AXEL RENANDER, M.D.
Secretary-General.

VISITS TO EUROPEAN CLINICS IN CONNECTION WITH INTERNATIONAL CONGRESS

The American Committee for the International Congress has found it impracticable to arrange for clinics in the various European centers at fixed times. The Committee, however, wishes to inform all of those who will attend the Congress that all of the following European colleagues have extended invitations to Americans to visit them before or after the Congress: Prof. Dr. Artur Schüller, Wien IX, Garnison-

gasse 7; Prof. Ferdinand Blumenthal, Berlin, Luisenstr. 9; Dr. Lars Edling, Lund, Sweden; Prof. Dr. Martin Haudek, Wien VIII, Langelasse 63; Dr. Hans Holfelder, Thorwaldsenplatz 6, Frankfurt a.M.-Sud; Dr. Edv. Collin, Finsen's med. Lysinstitut, Copenhagen; Prof. Dr. R. Grashey, Munich; Prof. Dr. Fedor Haenisch, Klopstockstrasse 10, Hamburg.

There are undoubtedly many others who will be glad to receive a visit from American roentgenologists from whom formal invitations have not been received. The information received by the Committee indicates that there will be a large attendance of Americans at the Congress, but that they are sailing in small groups at different times; some in May, some in June, and some in July. The only feasible plan for visits to European clinics would seem to be that each individual or small group should correspond directly with those whom it is desired to visit and arrange for definite dates. The letters from our European colleagues indicate that nearly all of them will be absent from their clinics after the middle of August. It is the opinion of the Committee that visits to the clinics will be much more profitable if they are made before the Congress rather than afterwards.

AMERICAN MEDICAL ASSOCIATION SECTION ON RADIOLOGY

The program for the Section on Radiology is now being completed, and a good, well balanced series of papers is assured. All are urged to attend, for we must fully exercise the privilege extended to us by the parent body, that depends for its strength on the faithful adherence of all its units. The attendance will be large, so make your hotel reservations early.

The next Annual Session will be held at Minneapolis, Minn., June 11-15, inclusive.

TO THE OFFICERS AND MEMBERS OF THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

When Dr. Lafferty started to make his remarks at the Counselors' dinner at New Orleans and up to almost the close of the same, I had no idea whom he was addressing or what he was leading up to; so that when, at the end, he presented me with that beautiful medal as a "Token of Service" I was so completely dumfounded that for the first time in my life I was rendered speechless. Feeling that I should at least express my appreciation, I take this method of so doing.

I am very proud of the Radiological Society, and of the small part that I have had in its development. I have been very glad to be able to render the little service to the Society, and have been very happy in so doing. If it has added anything to the general good of radiology and radiologists. I am fully repaid. I realize how pleasant it is to be appreciated, and, knowing that, I desire to publicly thank you and assure you that I am, and hope long to continue to be, at your service.

Sincerely,

I. S. TROSTLER.

SPECIAL ANNOUNCEMENT

The Thirteenth Annual Convention of the Catholic Hospital Association of the United States and Canada and the Second Annual Hospital Clinical Congress of North America will be held in the Cincinnati Music Hall, Cincinnati, Ohio, June 18 to 22, inclusive, 1928. The Fourth Annual Convention of the International Guild of Nurses will be held at the same time, in the same building, at night meetings.

This Convention and Congress will be one of the largest and most important hospital meetings of the year, and will comprise

general scientific meetings, special clinics or demonstrations of hospital departments, and three hundred special commercial and educational exhibits. Outstanding authorities in medicine, surgery, pathology, nursing, dietetics and hospital administration, architecture and engineering will lecture and demonstrate in specially planned clinics representing the various departments of the modern hospital. A professional program of the highest interest and value is now being formulated, and all persons interested in medical and hospital service are cordially invited to attend.

Further information may be obtained from John R. Hughes, M.D., Dean of the College of Hospital Administration, Marquette University, Milwaukee, Wisconsin, who is General Chairman of the Convention and Congress.

INDIANA ROENTGEN SOCIETY

The Indiana Roentgen Society was organized in Indianapolis on January 28, 1928, with the following officers: *President*, Dr. R. C. Beeler, of Indianapolis; *President-elect*, Dr. H. J. Pierce, of Terre Haute; *Vice-president*, Dr. L. F. Fisher, of South Bend; *Secretary-Treasurer*, Dr. C. S. Oakman, of Muncie.

"CHICAGO'S GREATEST RADIOLOGICAL SESSION"

The Radiological Society of North America will meet in Chicago, December 3 to 7, inclusive, 1928. This will be the Fourteenth Annual Session of the Society.

The Drake Hotel, located on Lake Michigan at North Michigan Avenue, has been selected as the headquarters during this session. The location of the Drake Hotel, just on the north edge of the Chicago business,

theater and hotel district, on one of the most noted and attractive boulevards of the city, is, indeed, desirable. The Radiological Society has been assured of ample space and the best of service and facilities to take care of the meeting. Exceptionally reasonable rates have been arranged for at the Drake.

The local committees have been organized and are already functioning with the idea of making this a splendid meeting of our Society. It is planned to have large scientific and commercial exhibits.

As Chicago is located nearly in the heart of our country, the attendance record should be the largest in point of number of any of our sessions.

Plans are under way to secure reduced railroad transportation rates.

The local ladies' entertainment committee has already started plans for the reception and entertainment of the visiting ladies.

We have the assurance of the Program Committee that the scientific program will be intensely interesting and instructive. Plans are being made to gather together a program interesting and instructive alike to physicians specializing in radiology and to general practitioners and physicians engaged in other specialties.

The annual banquet will be held at the Drake Hotel, Thursday evening, December 6. All members and guests are cordially invited to attend.

Preparations are being made by the local committees for accommodations for at least 2,000 members and guests.

Make your plans for this year include "Chicago's Greatest Radiological Session."

The local committees will do all possible to provide the best facilities for this, our Fourteenth Annual Session. No effort will be spared to make this session of the Radiological Society the most successful from a scientific standpoint. A cordial welcome and gracious hospitality will be extended to all members and guests.

Further details in regard to the program and other matters of interest will appear in RADIOLOGY throughout the balance of the year.

THE LOCAL COMMITTEES

Executive Committee

Dr. Benjamin H. Orndoff, *Chairman*
Dr. M. J. Hubeny
Dr. I. S. Trostler

Scientific Exhibit Committee

Dr. Robert A. Arens, *Chairman*
Dr. C. J. Challenger
Dr. Paul G. Dick

Scientific Sessions and Clinics Committee

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Dr. Henry Schmitz
Dr. Mary Elizabeth Hanks

Banquet Committee

Dr. E. L. Jenkinson, *Chairman*
Dr. S. A. Portis
Dr. Adolph Hartung

"Illinois Night" Committee

President of Section on Radiology,
Illinois State Medical Society, *Chairman*

President Central Illinois Radiological
Society

President Chicago Roentgen Society

"Chicago Night" Committee

Dr. E. S. Blaine, *Chairman*
Dr. Emil Beck
Dr. M. M. Portis

Ladies' Entertainment Committee

Mrs. I. S. Trostler, *Chairman*
Mrs. M. J. Hubeny, *Vice-chairman*
Wives of all members of Chicago
Roentgen Society

Sub-committee on Reception

Mrs. R. A. Arens, *Chairman*
Mrs. E. S. Blaine
Mrs. W. T. Bronson
Mrs. C. J. Challenger
Mrs. C. E. Cook
Mrs. B. C. Cushway
Mrs. E. L. Jenkinson
Mrs. G. M. Landau

THE NORTHWESTERN RADIOLOGICAL TECHNICIANS' SOCIETY

By E. C. GRIERSON, President
SAINT PAUL, MINNESOTA

The organization of a technicians' society in the Twin Cities was a logical follow-up of the organization of the American Association of Radiological Technicians. The first meeting was held in March, 1922. There were seven technicians present. A campaign was launched to be conducted by telephone and letters and personal interviews to interest other technicians in such an organization. At the next meeting sixteen technicians and three physicians were present. Dr. Harry Oerting opened the meeting with a short address on the desirability of organizing a technicians' society

and expressed the belief that all physicians would uphold such a society if conducted along proper lines. Dr. O. B. Chandler read a paper on the History of X-rays. The late Dr. Archibald MacLaren offered the young society the use of the offices at 914 Lowry Building, St. Paul, as a meeting place. Later, many invitations were received, and throughout the year meetings were held in private offices or hospital X-ray departments, and we received a great deal of instruction on technic which was very valuable.

Each meeting brought new technicians to us and our number grew until, in April, 1923, we felt that we were established and that an organized society could be maintained. Up to this time we had been designated as a "get-together society." A committee was selected to draw up a constitution and by-laws to be presented at the next meeting. The constitution and by-laws were adopted, officers elected, and, for the first time in the history of this "get-together society," membership fees and dues were assessed. Because we felt that the society gave promise of something larger than a local Twin Cities organization, the name of "Northwestern Radiological Technicians' Society" was selected. Time has borne out this belief, as our membership is now scattered throughout the Northwest from the Mississippi River to the Pacific Coast.

Since the date of the election of the officers, the society has continued to meet each month excepting during the summer holiday time. The radiologists, physicians, and surgeons in the Northwest have shown a keen interest in this society and have encouraged us by giving papers, helping to conduct our meetings, showing an interest in all that we have accomplished, and recognizing us as auxiliary to the medical profession. For the last two years we have had a printed program covering the year's work, which we have faithfully carried out and which has covered more widely the field

of technical work. Also, each evening's program has been a continuation of the previous programs. This has increased the attendance because of the continuity of the lectures.

In the early days of this society a creed was adopted which has remained our creed. This creed was taken from the American Association of Radiological Technicians and I believe that it should go in this report. It is as follows:

"We believe that every radiological technician should work under the direct supervision of, and be directly responsible to, some member of the radiological, medical, surgical, or dental profession, such member being generally recognized in his profession as being qualified to do the work attempted.

"We believe that the selection of individuals to enter this field of work should be by professional men.

"We are opposed to the so-called schools (whether conducted by professional men or laymen) who urge the attendance of any or all laymen with the promise of speedy preparation and handsome remuneration for their services. In other words, we are opposed to strictly commercial schools.

"We believe that the standards for all plate and film work should be established by the professional man doing the work of interpretation, and that it is our duty to qualify ourselves to produce the desired standard.

"We believe that no expression of our opinion regarding treatment, diagnosis, or interpretation concerning any patient with whom we work should ever be made to other than the professional man to whom we are responsible."

Loyalty to the medical profession, high ideals, and ethical conduct have been upheld. Many of our members are registered technicians and belong to the American Association of Radiological Technicians, and the number is steadily increasing.

The first annual report of this society was published in 1925; the second in 1926; the third in 1927. It is the policy of the society to publish each year a full report of the year's work, thus enabling members who live too far away to attend the meetings to be informed regarding the work of the society and to have for reference the instructive papers given by physicians and members of the society. In December of each year a banquet is held in either St. Paul or Minneapolis. The invited guests are doctors who have contributed to our programs during the year. These banquets are most friendly in character and are professional and dignified. At the December, 1927, banquet, Dr. Frank Bissell, of Minneapolis and St. Paul, told us of the good will and approval which he found existed toward our society. We recognized that his support had much to do with bringing about this result and that his approval has been won by the attitude of this society and our loyalty to the ideals that have been handed to us directly from the medical profession.

Undoubtedly this society has most wonderful possibilities before it, the way is open, and, if we avoid the many pitfalls, we will have the full approbation of the medical profession.

AMERICAN ASSOCIATION OF RADIOLOGICAL TECHNICIANS

PROGRAM OF ANNUAL MEETING

April 23, 1928, Hotel Sherman, Chicago

9:30 A. M., Monday

Registration.

First section—Business meeting.

Committee reports.

2:00 P. M. Standard X-ray Company: Papers and discussion on X-ray Physics.

9:00 A. M., Tuesday, April 24.

Papers and discussions by physicians.

All replies are not yet in, but among those

who have already signified their intention of speaking are: Dr. E. S. Blaine, Dr. M. T. MacEachern, and Dr. M. J. Hubeny.

2:00 P. M. Acme International X-ray Company: Technical demonstration. Mr. Newman.

9:00 A. M., Wednesday, April 25.

Second section—Business meeting.

Unfinished business.

New business.

Election of officers.

2:00 P. M. At plant of Victor X-ray Company.

A Symposium on Technic.

Positioning of the Patient.

Mr. H. O. Mahoney.

Intensifying Screens.

Mr. J. B. Thomas.

Motion.

Mr. Glenn W. Files.

9:00 A. M., Thursday, April 26.

Papers by society members. (These will be listed fully in the regular program.)

2:00 P. M. Sherman Hotel.

Papers and moving pictures (medical).

The program may be changed somewhat from the order as listed here.

We are fortunate in assembling a wealth of fine material and are confident that this meeting will be a huge success.

H. A. TUTTLE, *Chairman.*

M. MCGUIRE

J. MCCULLOCH

E. HOWARD

The Program Committee.

ACID-PROOF CHEMICAL STONEWARE

In a concise, tabulated, 4-page folder the U. S. Stoneware Company, of Akron, Ohio, answers the question, "What is Acid-proof Chemical Stoneware?" and for those interested gives photographs, diagrams, specifications, and prices of their product including

one-piece developing tanks, one-piece solution tanks, developing outfits for dental work, film and plate tanks with hanger ledge, laboratory sinks, dental trays, developer jars, and acid pitchers.

BOOK REVIEWS

LEHRBUCH DER ROENTGENDIAGNOSTIK, MIT BESONDERER BERUECKSICHTIGUNG DER CHIRURGIE. Edited by H. R. Schinz (Zurich), with collaboration of W. Baensch (Leipzig) and E. Friedl (Zurich). Contributions by A. Hotz, O. Juengling, E. Liebmann, E. Looser, and K. Ulrich. With an Introduction by P. Clairmont and E. Payr. With 1722 illustrations, many colored; 5 photographic plates. Published by Georg Thieme, Leipzig, 1928, XVIII, 1131 pages. Price, unbound 90 Marks; bound 98 Marks.

This is an enormous work, and an unusually excellent one. The editors had the proper idea of omitting from the work all clinical illustrations, and, instead, limiting it to a true roentgenology. The authors have succeeded in presenting to the readers all the important advances in diagnosis, in every branch of clinical medicine, by means of the roentgen examination, critically analyzed, and discussed with special reference to anatomical and functional foundations. In no single chapter can it be said that the roentgen aspect has been over-emphasized. It is indeed a pleasure to read the work through word by word, although many sections really require time and thought for a thorough appreciation. The bulk and the completeness of the assembled material are indeed astounding.

The first 26 pages are devoted to the theory of the roentgen image, general methods of examination, and the various

arrangements for protection. Especially happy and necessary is the emphasis laid on the distinction between *findings* and *diagnosis*, a matter which is not always sufficiently appreciated. Equally important is the contention that to obtain a proper interpretation of the roentgenogram not only is medical knowledge necessary, but also a special knowledge of technic; *i.e.*, particular attention to the geometrical conditions of the exposure is absolutely essential. This is a point of view that is still very much neglected in purely clinical quarters.

The next chapter is a long one of 430 pages on the roentgen examination of bones and joints. There is, first, a discussion of general fundamentals, in which variations of the skeleton are somewhat briefly dismissed; very likely on account of the slight surgical interest in this subject. Then there is a more detailed exposition of the various groups, beginning with the osteoporoses, osteoscleroses, and bone hypertrophies, among which acromegaly and tumors of the hypophysis are discussed minutely. The next section, on fractures and fracture healing, can be read with great pleasure and profit. Here there is almost constant emphasis on the fact that the roentgen signs depend upon the physical conditions, the anatomic form, and the functional status. In the discussion of torsion fractures of the tibia I was very much pleased to see mention of the extremely frequent combination with fracture of the fibula just below its head. The next section, on inflammatory bone diseases, is thoroughly worked out, as its importance requires, and is illustrated very effectively, like the chapter on fractures. The correlation of the pathologic-anatomic, the clinical and the roentgenological findings is very complete.

There is a section on bone tumors, with a description of systemic diseases and their sequelæ, which is written by both Looser and Hotz. Here the cysts, giant cell tumors,

and central fibromas are particularly well written up.

The chapter on injuries and diseases of the joints is introduced by a description of the normal anatomy of the joints. In the discussion of luxations I was rather surprised to see the retention of the term "central luxation," and at the same time was pleased to see a description of the little known and yet so common Bennett's fracture (base of first metacarpal).

In the description of acute and chronic joint diseases the preliminary discussion of the anatomical substrata is a great aid to the appreciation and understanding of the roentgen findings. Also, in the next chapter, on the various aseptic epiphyseal necroses and apophyseal disturbances, which are known under such a variety of names, the X-ray findings are developed for us from the pathologic-anatomic foundations. In connection with Koehler's disease, I was rather surprised to find that the author ascribed as an uncontested etiology the idea of mild trauma of the scaphoid, which is the last of the tarsal bones to ossify. This traumatic etiology was the one which the reviewer was the first to present in 1908. However, although this has been steadily combated from numerous sources, the author has completely ignored all the evidence for the opposing views.

Deformities are given somewhat more consideration. The slight knowledge of the roentgen findings in the various disturbances of growth and development is very thoroughly worked up. The roentgen diagnosis of the skull is presented by Ulrich. The chapter on ventriculography is written by Juengling. By means of many typical cases, most of them with brain specimens, he has presented very clearly all the possibilities of localization in the most varied types of brain tumors. The technic is thoroughly described, with particular attention given to the various errors that might be

produced. There is a short section on myelography and one on foreign bodies in the skull.

The next long chapter (340 pages) is on the X-ray examination of the thoracic organs. The normal relations are especially well described, as required by their importance and complexity. The study of the pathologic chest image is again introduced by general fundamental considerations. Ulrich describes the trachea, and Liebmann the diseases of the bronchi. Liebmann also presents an extensive section on diseases of the lungs. In this he adheres to a modification of the classification brought out by Graeff and Kuepferle. He believes that a strict division of tuberculosis into the exudative and productive types is difficult, and not always possible on account of the great frequency of borderline cases. Even more difficult is the attempt at classification in childhood tuberculosis (Hotz). There is a description of the indications for operative interference (pneumothorax and plastic surgery) as determined by the roentgen findings. Pneumokoniosis is briefly considered, as well as tumors of the bronchi and lungs, and other rarer pulmonary diseases. It is obvious that there is no attempt to limit the discussion to the domain of surgery. Von Liebmann also contributes the description of pleural diseases, although the portion devoted to children is handled by Hotz. Further sections concern the diseases of the diaphragm, the heart and great blood vessels, and also the mediastinum.

The examination of the digestive tract takes up the next 275 pages. In the previous chapters on the lungs emphasis was laid on the fact that fluoroscopy alone and without adequate film or plate exposures was not sufficient. Here it is equally well pointed out that the most beautiful roentgenograms are not sufficient for a diagnosis. Fluoroscopy is absolutely indispensable.

In the section on stomach and duodenum

there is a description of the technic of examination, followed by a discussion of the normal roentgen image, with special reference to anatomy and physiology. The pathological study begins with a consideration of peptic ulcers. The author maintains that niches are due more to the heaping-up of the mucous membrane than to spastic contractions. In a special section there is a consideration of the various technical methods of examination, with particular reference to sources of error, such as pressure from extra-gastric organs and pressure from the vertebral column in the prone position. In the consideration of gastric cancer there is again reference to the general roentgen symptomatology produced by the functional disturbances and the anatomical changes. In the special roentgen study there is a description of the various localizations and varieties of cancer. Especially helpful is the discussion of the value of the diagnosis of "gastric tumor," and the estimation of operability. Here is stressed the great necessity of a close co-operation between the special roentgenologist and the surgeon. It is maintained that gastric cancer can be determined more safely and in a greater percentage of cases by the roentgen method than by any other clinical methods of study. Among the rarer affections of the stomach and duodenum, actinomycosis, lues, tuberculosis, and pyloric stenosis are discussed. The novice is warned that these conditions do not present any pathognomonic X-ray signs, and no strictly X-ray diagnosis is possible.

In accordance with the general plan of the work, the sections on the small and large intestines are also considered from the aspects of normal X-ray image, exposure technic, morphology, and physiology. Many examples of the X-ray findings in ileus are described. Diseases of the small intestine are only briefly considered. Colonic diseases, on the other hand, are given much

more space. Pneumoperitoneum is considered as not strictly harmless, and should be confined to cases with very definite and specific indications. In a separate appendix the X-ray findings in disease of the liver, spleen, and pancreas are considered. There is a description of the normal gall bladder, cholelithiasis, and cholecystitis, as well as reference to liver exposures and cholecystography.

The last important chapter is on the urinary organs (38 pages). In the reviewer's opinion there is too much skepticism about the X-ray diagnosis of nephrolithiasis, or, rather, too little reliance on real experience. Personally, I would also dispense with a general Bucky exposure. Normal findings, anomalies, and diseases are considered in the kidneys, ureters, and bladder. The urethra is also discussed.

The book closes with a very complete index. The entire work is profusely illustrated with excellent and characteristic roentgenograms, carefully selected and reproduced with great beauty and clearness. The type and paper are of the best. The care and effort that the publishers have lavished on the production of this volume have resulted in giving the truly wonderful contents a most desirable setting.

Altogether the work is to be considered as one of the very finest, and should not be missing from any roentgenologic library. It will certainly secure many new friends and supporters for roentgenology.

PROF. DR. F. HAENISCH (Hamburg).

(Translation by ISAAC GERBER, M.D.)

INTERNATIONAL CLINICS, 1927, III. A Quarterly of Illustrated Clinical Lectures and Especially Prepared Original Articles. Published by J. B. Lippincott Company, Philadelphia and London.

The material in this volume is presented in the usual well written, well arranged manner, which makes it especially easy as a reference text for the busy physician. The volume is divided into sections devoted to diagnosis and treatment, medicine, surgery, obstetrics, neurology, medical history, and post-graduate study. Under the section devoted to diagnosis and treatment the subjects covered are many and varied. Among them may be mentioned "The Passing of Disease from One Generation to Another and the Processes Tending to Counteract It," by Theobald Smith; "The Electrocardiographic Study of the Various Forms of Heart-block," by John Miller Wilson; "Colitis—Catarrhal, Mucous, Ulcerative," by T. R. Brown; "Clinical Aspect of Thromboangiitis Obliterans," by William A. Steel; "Differential Diagnosis and Treatment of Gall-bladder Disease," by I. W. Held and Irving Gray; "Medical Treatment of Peptic Ulcer," by John Phillips; "Meckel's Diverticulum," by L. F. Barney; "Anemic Spinal Diseases," by Dr. Nonne, of Hamburg, Germany; "Field Investigations of the U. S. Public Health Service," by A. M. Stetson.

In the section of medicine appears a report of 20 cases of pneumococcus meningitis and endocarditis; consideration of treatment and review of literature, by Hyman I. Goldstein and Henry Z. Goldstein.

In the section devoted to surgery appears "Deformity-correcting Splints for Fractures of the Long Bones," by H. C. Masland.

The section devoted to obstetrics covers "Kielland Forceps and Vesicovaginal Fistula," by Daniel Longaker and Walter F. Harriman, both of the Kensington Hospital, Philadelphia.

The section on neurology covers "Palanesthesia (Loss of Vibratory Sense)—an Early Diagnostic Sign of Combined Scle-

rosis," by E. D. Friedman, of the University and Bellevue Hospital Medical College, New York.

The section devoted to medical history is written by John Rathbone Oliver, A.B., M.D., Ph.D. The section devoted to post-graduate study is edited by H. W. Cattell, M.A., M.D., Fellow of the College of Physicians, Philadelphia. The section on personal, community and industrial hygiene is edited by Walter S. Cornell, M.D., D.P.H., Director of Medical Inspection of Public Schools, Philadelphia.

Of the articles most worthy of consideration from the radiological standpoint the reviewer would like to call attention to the article on colitis, by Thomas R. Brown. This article covers the subject of colitis in an excellent and instructive manner. A perusal of this article will give the radiologist much helpful information. The symptomatology and pathology described should be quite helpful in the interpretation of films taken in studies of colitis pathology.

The article on gall-bladder disease, diagnosis and treatment, by I. W. Held and Irving Gray, is a complete résumé of the present status of our knowledge of gall-bladder pathology, diagnosis, and treatment. The portion of this article devoted to the radiological diagnosis of gall-bladder disease is well written and contains the most recent and up-to-date information.

The questionnaires appearing in the section on post-graduate study, listed as "Medical Questionnaires," are well worth reading as a test of one's knowledge of modern medical questions.

The section on "Community Hygiene," by Walter S. Cornell, contains much practical information relative to hygiene which is very valuable to have on hand in the library for reference.

B. C. CUSHWAY, M.D.

INTERNATIONALE RADIOTHERAPIE. Besprechungswork auf dem Gebiete der Röntgen-, Curie-, Licht- und Elektrotherapie. Begründet und herausgegeben von J. Wetterer-Mannheim, in Gemeinschaft mit F. Bardachzi-Aussig; D. Chilaidditi-Konstantinopel; R. Gassul-Kasan; W. Lahm-Chernnitz; Henry Schmitz-Chicago; F. Sluys-Brüssel; J. Solomon-Paris; M. Spinelli-Neapel. Band II. Greenbuckram, 1092 pages. Published by L. C. Wittich, Darmstadt, Germany, 1927. Price 64 R.M.

This is a second volume of a most valuable International Review of all the publications devoted to roentgenotherapy, radiumtherapy, heliotherapy and allied subjects, including the physics, biological effects, biochemistry, apparatus, dosimetry, protection, etc.

The undertaking of such a publication is a gigantic and almost colossal task, but the editors and collaborators have succeeded remarkably well in bringing together practically all that has been published upon the subjects, and in a manner that makes the contents accessible to a degree seldom attained in similar publications. The book is the product of the labors of forty-six reviewers in Europe, South America, Japan, and the United States, is well indexed and cross-indexed, and the different subjects and allied subjects are well grouped, and grouped together.

The book is divided into three parts, namely: References, Surveys, and Appendix. Part I, consisting of references, contains twelve chapters upon the subjects of Physical and Technical Radiotherapy and related subjects, Biological Effects, Dermatology, Gynecology, Malignant Tumors, Tuberculosis, Internal Tumors, Renal and Venereal Diseases, Stomatology, the Eye, the Infections. Each of these chapters is divided into special subjects, which are, of themselves, separately indexed, so that

search for any particular subject is both easy and rapidly accomplished.

Part II consists of surveys of the different branches of radiotherapy by authorities of world renown, and from their viewpoint. Our Arthur W. Erskine contributes a comprehensive discussion of "Roentgen Dosimetry in the United States in 1926-27."

Part III is an appendix of 49 pages by W. Lahm, embracing special subjects, and is in itself an almost invaluable library. It is divided into a general part and special parts under the main headings of Superficial and Deep Therapy, which are again subdivided into the special conditions and indications, in the most modern and satisfactory manner.

A general historical account of "the development of roentgenotherapy from the beginning of the roentgen era," by J. Wetterer, is most interesting and entertaining.

The first edition of this book represented the subjects in 1923 to 1925, while the present volume brings the publications up to the time of printing. The first edition was very well received, and this volume should meet with an even better reception by radiotherapists. As before stated, this volume represents the combined work of many readers, well arranged, and brought together so as to make it a most desirable and useful work. In the opinion of your reviewer, it is the most valuable reference book upon the subject discussed.

I. S. T.

SURGERY OF NEOPLASTIC DISEASES BY ELECTROTHERMIC METHODS. By GEORGE A. WYETH, M.D. Pages 316. Price \$7.50. Paul B. Hoeber, Inc., New York, 1927.

The writer explains the nomenclature involved in this new field of surgery. An outline of the history and production of

high frequency currents is given. The term "endothermy" is selected for use where the high frequency current is used to develop heat from within the tissues. Endothermy includes desiccation, coagulation, and the use of the endotherm knife. Its purpose is to seal lymphatics and destroy malignant cells.

The monopolar endothermy or desiccation is used for small superficial lesions, malignant or benign. The technic is described. The treatment is carried out under a local anesthetic with practically no bleeding. Where deeper destruction is wanted the bipolar or diathermy is used. Here the heat is developed between a small active electrode and a larger inactive one. The endotherm knife is an active electrode used with a very high frequency current. There is such rapid destruction of the cells that the electrode,

not truly a knife, passes through the tissues with the speed of a knife. There is more or less sealing of the edges of the wound, very little bleeding, and probably sealing of the lymphatics. Tumors which otherwise would be inoperable because of the bleeding can be handled safely.

The greater part of the book is devoted to case histories and a description of the technic used in treating. The author reviews the literature on mouth cancer and indulges in caustic remarks when an opinion is stated which differs from his own.

There is no question but that electrothermy is one of the greatest discoveries of the age. However, it has not been found possible to measure accurately the current used, so that the technic varies with the operator and the subject. No method of standardizing the technic has been found.

ABSTRACTS OF CURRENT LITERATURE

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Regarding the Influence of Roentgen Rays on the Effectiveness of Insulin. E. Vogt. *Strahlentherapie*, 1927, XXVII, 106.

Insulin in solution (1 c.c. contained 20 units) was exposed to a mercury vapor lamp at 30 cm. distance, for a period of ten minutes, or to roentgen rays (220 K.V., 4 ma., 0.8 Cu. plus 1.0 Al., dose corresponding to the average erythema dose). The studies of the blood sugar fluctuations following the injection of the irradiated insulin were done on pregnant women. Control tests showed that the insulin was activated by the irradiation; the change is perhaps of a chemical nature.

E. A. POHLE, M.D.

A Valuable Roentgenographic Aid in the Diagnosis of Intestinal Obstruction. Kenneth S. Davis. *Am. Jour. Roentgenol. and Rad. Ther.*, May, 1927, XVII, 543.

The writer describes a simple X-ray procedure which he has in some cases found to give valuable diagnostic aid in locating with fair accuracy the site of obstruction in cases where the intestinal obstruction is complete. A single 14×17 "scout" film of the abdomen and pelvis is made without preparing the patient in any way. In cases of small bowel obstruction the small intestine was found to be distended with gas, but the colon either was not seen or contained only a little gas, whereas in large bowel obstruction the colon proximal thereto was enormously distended, with the small bowel showing only moderate distention. The author finds the method not reliable in new-born babies because apparently the small bowel may be so distended as to give the appearance of a distended colon.

J. E. HABBE, M.D.

Radium Therapy: Reports from Research Centers. *Brit. Med. Jour.*, Dec. 24, 1927, No. 3494, p. 1193.

The three main lines of treatment which have been followed are: (1) combination of surgical measures with radium therapy; (2) insertion of the element into the tissues; (3) its superficial application.

In carcinoma of the cervix, the introduction of a single tube of radium into the cervical canal has been proved to be inadequate unless supplemented by the insertion of the tube into the cervical tissues or the introduction of a large number of tubes of low radium content into the cervical tissues.

The technic adopted in carcinoma of the larynx at St. Bartholomew's Hospital includes the making of a large window in the thyroid cartilage, so as to allow the needles to be placed as close to the growth as possible.

In carcinoma of the rectum, colostomy is advised before treatment by radium is commenced, though removal of the coccyx is not advocated.

In carcinoma of the breast, the technic of employing large quantities of radium acting over a short period of time is being compared with that of employing a number of distributed foci containing small quantities of radium over a long period of time.

H. W. D. MACKENZIE, M.D.

Deposition of Calcium Salts in Areas of Calcification. James Crawford Watt. *Archiv. Surg.*, July, 1927, XV, 89.

The deposit of calcium in bone is in an extremely fine form and in such a manner that from appearances alone it might be interpreted either as a secretory phenomenon of the osteoblasts and bone cells or as a precipitation phenomenon. Correlated with physiologic evidence, however, the balance of proof is in favor of the secretory view. The object of this investigation was to learn whether such was also the case in areas of calcification.

Several observers agree that calcium is carried in the blood in some more soluble form, either as a colloidal albuminate, neutral calcium phosphate, or double salt of calcium carbonophosphate, any of which could be the means of transport to the tissues where precipitation could be produced, causing deposit of the calcium.

The author concludes: "Areas of pathologic calcification were studied on human material from the pineal gland, the choroid plexuses of the lateral ventricle and third ventricle, the thyroid gland, and various arteries.

"The deposits were shown to be calcium by their optical appearance in unstained sections and their reaction to polarized light, also by staining reactions, by their removal by acids and by the similarity of their appearance to that of calcium salts precipitated in colloids.

"There is no evidence of any cellular activity concerned in the deposition of the calcium salts. There is evidence for their appearance here by precipitation.

"The precipitation may be originally in the form of carbonate and phosphate of calcium, or may be as a calcium soap formed by reaction with a fatty acid, and later gradually converted into the carbonate and phosphate.

"Iron was found combined with the calcium deposits in the nervous system."

LE ROY SANTE, M.D.

Peptic Ulcer—from the Standpoint of the Radiogram. A. Stanley Kirkland. Can. Med. Assn. Jour., May, 1927, XVII, 538.

The pathognomonic signs of gastric ulcer are a niche on the lesser curvature, and a corresponding incisura opposite. These signs may be simulated by spasm, which may be secondary to duodenal ulcer, cholecystic disease, chronic appendicitis, or pancreatitis. The exhibition of belladonna does not always relieve the spasm produced by perigastric cancer or duodenal ulcer. The differentiation is in such cases extremely difficult.

Secondary signs of gastric ulcer are chiefly delay in emptying time and localized tenderness.

Duodenal ulcer provided 94 per cent of all peptic ulcerations in this series of 2,000 gastro-intestinal case reports. It often gives a pathognomonic train of symptoms. Even in such cases X-ray examination is necessary to clinch the diagnosis and point the way to treatment. In many instances, however, the symptom complex is misleading and the X-ray is necessary to clear up a diagnosis.

The radiological investigation of the stomach and upper small bowel should proceed in the most painstaking way. Fluoroscopic observation in the erect and prone positions should be followed by serial radiography.

The cardinal findings in duodenal ulcer are, again, the niche and incisura, but reversed in order of importance as compared with gastric ulcer.

Associated findings in duodenal ulcer are associated spasm, localized tenderness, decrease in normal mobility, and increase in peristalsis.

Jejunal ulcer develops only as a sequel to gastro-enterostomy—a fairly common sequence. The X-ray will show a hypertonic, hyperperistaltic stomach, with a definite, sharply defined point of exquisite tenderness over the stoma. The meal cascades rapidly over the ulcer into the bowel.

In the matter of treatment the X-ray provides very definite indications of the procedure to be adopted. The determination of a perforating or penetrating ulcer of the stomach wall is an indication for immediate surgery. A wedge-shaped excision of the ulcer area is indicated. Gastro-enterostomy is usually not necessary. Surgery is necessary when there is deficiency in emptying of the stomach due to cicatrization about an ulcer at the pyloric ring or in the immediate neighborhood.

The radiologist should indicate, in the case of duodenal ulcer, whether medical or surgical measures should be adopted.

L. J. CARTER, M.D.

Report of Roentgen Society and British Institute of Radiology. Brit. Med. Jour., Nov. 26, 1927, No. 3490, p. 986.

Sir William Bragg looks forward to the forthcoming International Congress of Radiology in Stockholm as a means of establishing a definite standard of X-ray measurements, to enable comparison of the work from different parts of the world.

Sir James Purves-Stewart discredits the use of opaque injections of ascending lipiodol (11 per cent iodine in olive oil) in the investigation of the central nervous system, but gives one important exception, namely, its justification in determining the lower level of compression due to a spinal cord tumor. Such use is rare, however, because surgeons regard

determination of the upper level as more important.

Sir John Thomson-Walker, in discussing pyelography as an aid in the diagnosis of renal disease, enumerates the changes in the pyelogram indicative of renal pathology. He goes on to discuss objections to the method developed in Paris under the name of "pyeloscopy" in investigating the renal pelvis, and says that he has evolved a method of seropyelography in which, after the first pyelogram, the catheter is withdrawn and additional radiographs taken at intervals until the renal pelvis is completely emptied. The first point to decide is the time taken by a normal pelvis to rid itself of its contents after being fully distended. In some cases the pelvis emptied itself rapidly, no shadow being found at the end of two minutes. In other cases, without any appearance of abnormality, evacuation was completed only after three to five minutes. The longest time taken by a normal pelvis to empty itself was five minutes or a little over. He discusses various factors apart from pathological conditions which might influence the contractual efforts of the pelvis, and concludes by saying that seropyelography is easily applied and results in a permanent record, but, as the method is new, it is advisable to study normal as well as abnormal conditions.

Dr. L. S. T. Burrell, discussing the diagnosis of intrapulmonary disease, gives a new technic in the injection of lipiodol. He injects 14 to 15 cubic centimeters of lipiodol through the cricothyroid membrane, after anesthetizing the skin with 2 per cent novocain and injecting into the trachea 0.5 c.c. of 5 per cent

cocain. This method is particularly useful in the diagnosis of bronchiectasis.

H. W. D. MACKENZIE, M.D.

Regarding the Absorption Spectrum of the Corodenin in the Ultra-violet Region. P. Niederhoff. *Strahlentherapie*, 1927, XXVI, 634.

The author has investigated the absorption of ultra-violet rays in corodenin and finds that it absorbs considerable energy between 3,300 and 2,850 Ångströms and is almost impermeable for wave lengths under 2,600 Ångströms.

E. A. POHLE, M.D.

Fundamental Problems in the Radiation Treatment of Cancer of the Esophagus: Review of the Literature. Joseph M. Marcus. *Am. Jour. Roentgenol. and Rad. Ther.*, June, 1927, XVII, 637.

The author reviews the literature for the past twenty-three years on the various methods of treating carcinoma of the esophagus by attempted extirpation, gastrostomy, radium insertion into the esophagus followed by esophageal dilatation, and external X-ray therapy. The dangers of pulmonary accidents following therapy are emphasized and a case under the author's observation of perforation into the arch of the aorta which occurred four weeks after a single intensive dose of 2,400 milligram-hours within the esophagus is cited. Because of the dangers of hastening necrosis and perforation, the writer advises intensive radiation only in very early cases.

J. E. HABBE, M.D.

WANTED—Capable X-Ray film salesman and demonstrator. Should be young, well-educated and have pleasant personality. Good opportunity for man not afraid of hard work and extensive travelling. Answer by letter only and give complete details, including references.

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